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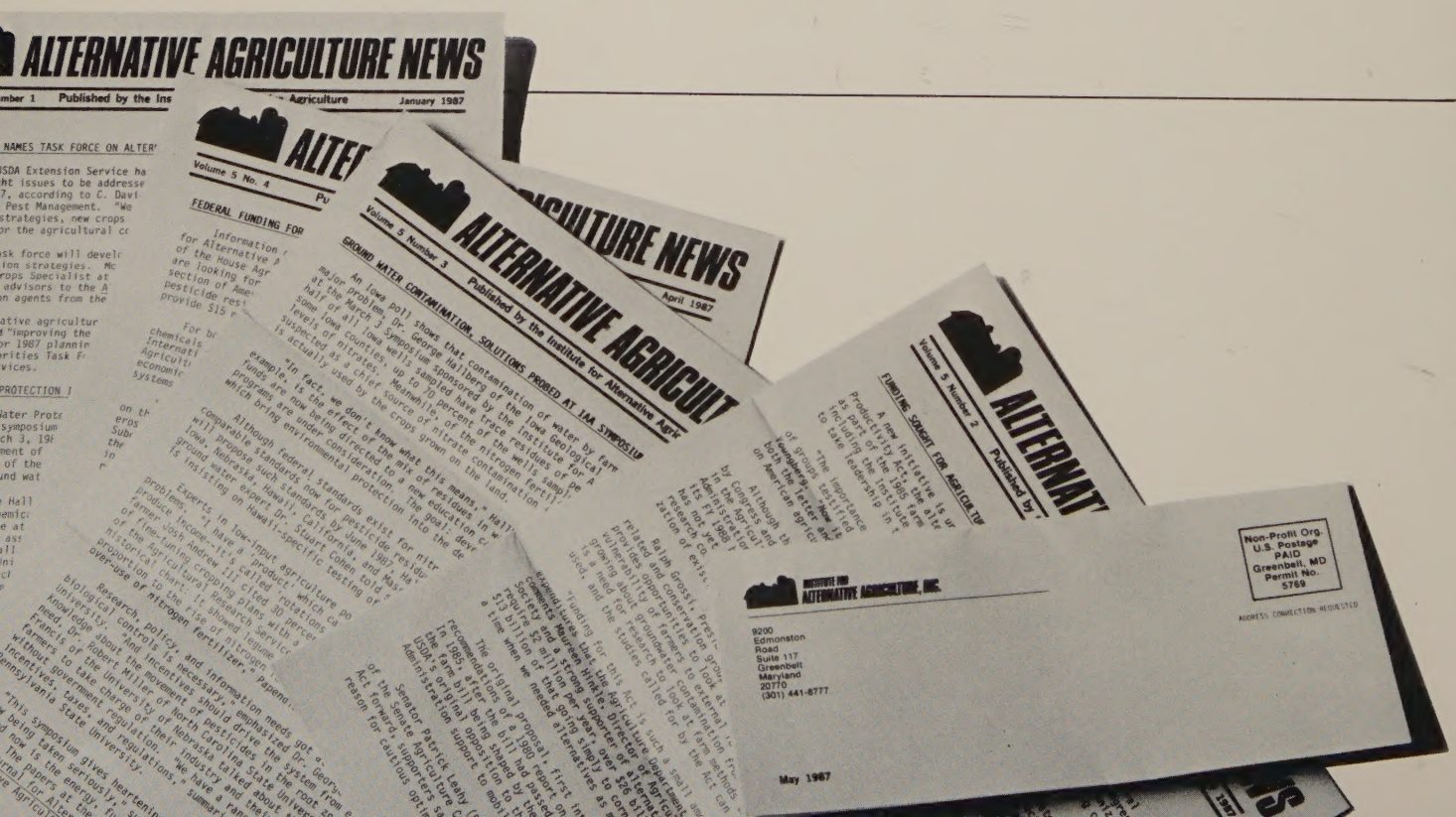
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TABLE OF CONTENTS

Articles

3 Traditional management of a hillside agroecosystem in Tlaxcala, Mexico: An ecologically based maintenance system
Daniel C. Mountjoy and Stephen R. Gliessman

11 Preferences for crop production practices among conventional and alternative farmers
Frederick H. Buttel and Gilbert W. Gillespie, Jr.

19 Weed seed destruction by arthropods and rodents in low-input soybean agroecosystems
Gerald E. Brust and Garfield J. House

26 Factors influencing the economic potential for alternative farming systems: Case analyses in South Dakota
Thomas L. Dobbs, Mark G. Leddy, and James D. Smolik

35 Improving the relevance of formal education and training in preparing international students as change agents for low-input agriculture
Kristin Cashman and Edgar Persons

43 Commentary: Resolving conflicts in American land-use values: How organic farming can help
Frederick Kirschenmann

Departments

Opinion—2 • From The Literature—17 • Resources—25 • Upcoming Events—34 • Book Reviews—41 • Institute News—48

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Institute Information

The Institute for Alternative Agriculture is a nonprofit, tax-exempt research and education organization established in 1983 to encourage and facilitate the adoption of low-cost, resource-conserving and environmentally-sound farming methods. It works closely with producer groups, public research and education institutions, and government agencies in promoting a sustainable agriculture system.

Its programs include providing a national information clearinghouse, serving as a voice for sustainable agriculture in Washington, and developing and implementing research and educational outreach programs. It holds an annual scientific symposium and publishes a monthly newsletter.

The Institute is governed by a grass roots Board of Directors, which includes several commercial-scale organic farmers, and maintains a small professional staff. It is supported by memberships and donations and grants from foundations, corporations, and individuals.

Cover

The cover photo depicts reclamation of eroded hillsides utilizing traditional slope management systems in Tlaxcala, Mexico. Sloped terraces combined with catchment basins (cajetes) conserve soil and water, trap nutrients, and allow for plant diversity. Photo provided by Daniel C. Mountjoy, Graduate Student in Human Ecology, University of California, Davis.

OPINION

Does organic farming require too much livestock?

Jim Bender

A characteristic feature of organic farming and related sustainable agricultural systems (hereafter just called "organic farming" in the interest of simplicity) is the integration of livestock husbandry with feed production. This facilitates recycling of livestock manure and the use of rotations involving legume forages. However, it also raises a potentially serious objection: If every farmer practiced it, the country might have more livestock than we need or want.

The question "what if everybody did it?" is legitimate, provided it is phrased accurately and fairly. One version might be: "What if all farmers attempted to use manure to replace their current use of fertilizer?"

Organic farming apparently fails this test. However, this question is based on three implicit assumptions that distort the nature of organic farming. First, it assumes the same cropping plan as is typical of conventional practice, e.g., from one-half to all the cropland in feed grains. Second, it assumes that manure needs to replace conventional fertilizer at the same rate. Third, it assumes that livestock manure is the only material that the organic farmer will wish to use as an alternative to inorganic fertilizer. All these assumptions are false, for reasons I discuss later.

Instead of focusing entirely on fertilizer requirements, I offer another test that reflects the relationship between livestock, efficiency, and conservation in organic farming: "What if livestock were always raised in a manner that conserves resources by using them efficiently, and that makes livestock and crop production mutually supportive?"

This version of the question has important implications for where livestock are produced. The trend has been towards large-scale confinement, rather than a farm-based system. This trend is not consistent with the second test of agricultural practices, for two reasons. First, because it is difficult to use manure from large-scale confinement lots efficiently, this system violates the requirement that livestock production support crop production. Second, confined livestock cannot use crop residues and grasslands, which violates the requirement that crop production efficiently support the livestock.

Jim Bender is an organic farmer near Weeping Water, NE.

It is not fair to evaluate the feasibility of organic farming grafting individual components of it onto the basic struct of the conventional system, such as the continued prevale of large-scale confinement feeding. Yet this is what the f question assumes. If livestock for organic production w merely added to livestock currently produced in large-sc confinement, the total would indeed be excessive. But m large-scale confinement is inconsistent with the basic idea organic farming. The criticism that there would be too mu livestock places the responsibility for the surplus on the orga farming component, rather than the confinement facilities.

Suppose, instead, that livestock now raised in large-sc confinement were returned to farms to enhance organic syste To take the example of beef cattle, in 1981 there were ab 17 million head of cattle fed in large-scale confinement (at le 1000 head) in the 23 states comprising the major cattle feed region. By contrast, cattle fed on farms numbered only 6 n lion, out of a total of about 23 million. Therefore, if there w no large-scale confinement feeding, the number of cattle fed farms could be increased almost four-fold without increas the total number.

How much livestock does organic farming require? The sirable livestock herd on an organic farm is the number requi to meet soil conservation requirements, to reduce fertili needs and enhance soil structure by recycling nutrients a organic matter, to provide financial diversity and stability, a to permit reduction or elimination of pesticide use. The num needed to achieve these goals is not as large as is commo believed. The following model of a moderate sized farm provi an estimate. Obviously, it is only an illustrative example.

The farm has 320 acres of land typical of the Corn Belt a Plains, mostly in row crops, but with a few acres of steep rough land. The livestock herd has 30 cows and one bull, w 27 calves. Also, 26 yearlings are finished per year on the fa including replacement heifers. Would this meet the requ ments of organic farming?

From the viewpoint of soil conservation, a few acres are suited for pasture, and there should be grassed waterways. 30 cows provide a financial return for these conservation n sures by consuming the grass harvested from the rough gro

continued on pag

Traditional management of a hillside agroecosystem in Tlaxcala, Mexico: An ecologically based maintenance system

Daniel C. Mountjoy and Stephen R. Gliessman

Abstract. *Traditional agricultural systems are increasingly being recognized as important examples of ecologically sustainable production methods and as such deserve agroecological attention. In a study of terrace agriculture in Tlaxcala, Mexico, the authors identify several management features which have been used for as long as three thousand years. The theoretical approach employs the notion of open versus closed agroecosystems for examining soil and water management, species diversity, and nutrient cycling. In the traditional system, conservation of existing resources is the distinctive feature whereas, with modern techniques, the emphasis is on replacement. The most distinctive feature of the Tlaxcalan agroecosystem is the terrace/cajete complex which serves to contain heavy downpours and trap eroded soil, ensures diversity of plant species, and traps and concentrates nutrients. The functioning of this traditional system is endangered by new management strategies that have responded to external political, economic and social pressures for change. This article discusses the ecological repercussions of these new practices and suggests ways that appropriate elements may be integrated to promote the sustainability of food production.*

Key words: agroecology, water management, sustainable agriculture, food needs, increasing population

Introduction

Traditional farming systems are rapidly changing in all areas of the world as economic pressures and the availability of new technologies promote the increased adoption of modern agricultural practices. Sustainable production based on local inputs is being replaced by an increasing dependence on costly external inputs in order to maintain productivity. Given accelerated soil erosion, the accumulation of toxic chemicals, and a reliance on diminishing and unpredictably priced petroleum resources, the long run adaptive value of these changes is being questioned by farmers and economists alike. The need to identify the ecologically sustainable features of traditional agriculture is now being recognized as part of a strategy to meet the long range food needs of an increasing world population (Cox and Atkins, 1979). Knowledge of management methods that have sustained production in traditional agricultural systems for as much as three thousand years (Abascal and Garcia, 1975) can be integrated with present-day economic pressures and appropriate agricultural technologies to insure long-term productivity and stability (Altieri and Anderson, 1986).

The purpose of this study was to identify the factors involved in the sustained functioning of a traditional agroecosystem in highland Mexico and to draw attention to the ecological repercussions of some modern management strategies that have been adopted.

Theoretical framework: Open and closed agroecosystems

The theoretical model for this analysis is based on the distinction between natural and agricultural ecosystems as proposed by Smith and Hill (1975). Their model forms a continuum between highly diverse and non-managed natural ecosystems, and the more simplified and intensive human intervention of agricultural systems. The many variations of agricultural ecosystems found worldwide also can be placed along a similar continuum. Traditional subsistence agroecosystems more closely resemble natural ecosystems since genetic diversity is high (Geertz, 1963; Allison, 1983), energy input is from solar and human sources (Rappaport, 1971; Pimentel, 1984) and nutrients are cycled within the agricultural system (Gliessman and Amador, 1980). Modern mechanized agriculture lies at the other end of the continuum with diminished diversity, and an outflow of energy and nutrients in the form of the harvest. In contrast with the more 'closed' cycling of traditional subsistence agriculture, modern systems require energy and nutrient imports to compensate for the 'open' cycling of crop products in a world market (Pimentel, 1984).

For the purposes of this article, the use of 'agroecosystem' will include the

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entire farm system since in traditional communities the residents consume the harvest and provide human labor as an input and are thus integral to the 'closed' system (Hart, 1979). Since in the region of this study no farmer actually uses only traditional or only modern practices, the degree to which the agroecosystem is 'open' or 'closed' is used as a measure of change and to identify losses or removal from the system.

Three elements of rainfed agroecosystem management in Tlaxcala, Mexico, were examined: soil and water conservation, species diversity, and nutrient cycling. Field work was conducted from June 28 to October 1, 1984, and involved the collection of quantitative field measurements, as well as on-site interviews in two communities with 16 farmers who use a broad range of agricultural techniques (Mountjoy, 1985). One of the towns was selected as representative of lower valley slopes while the other was located in a ridge top environment. Three farmers, representing three distinct management strategies, were selected for in-depth interviewing. Despite the small number of farmers interviewed, it is felt that they fairly represent the diversity of field locations and field management systems encountered in the region. Detailed field mapping and sampling were conducted in their fields. The three strategies were 1) multicropping with manure, 2) multicropping with synthetic chemical fertilizer and manure, and 3) monocropping with synthetic chemical fertilizer and manure. Local governmental agencies working with agriculture and land use were also interviewed about their programs with the farmers in the region.

Environmental setting

The state of Tlaxcala is located 200 kilometers east of Mexico City. The focus of this study is a hill region at 2200 meters elevation. Two major factors influence agricultural production in this region, as in all of highland central Mexico: rainfall and soil structure. Rainfall in the entire region is concentrated between May and September and occurs in sudden downpours which often exceed 20 mm in less than 30 minutes. The soils of Tlaxcala, like those of the rest of the volcanic highlands, are composed of layered ash falls that have subsequently developed into alternating layers of duripan *(tepetate)* and clay soils. As long as these underlying layers are protected by the shallow A horizon they serve as reservoirs of nutrients and moisture which are available to plant roots. The slopes of these hills, however, are especially prone to erosion during the heavy rains and the loss of the topsoil leads to the transformation of the *tepetate* into an impermeable layer not suited to cultivation. Conservation of the vulnerable top soil is thus a primary focus of hillside agricultural management in highland Mexico.

Table 1. Size of catchment structures *(cajetes)* in four hillside agroecosystems and regional average fo Tlaxcala.

Field Type	Average Length (m)	Average Depth (m)	Average Width (m)	Average Volume (m^3)	Avera Divid (m)
1. Established protected slope	5.47	0.60	0.69	2.26	0.63
2. Established exposed ridge	3.72	0.64*	0.53	1.26	0.81
3. New protected slope	2.98	0.54	0.57	0.92	0.75
4. New exposed ridge	4.95	0.58*	0.94	2.70	0.51
REGIONAL AVERAGE:	4.28+.98	0.59+.04	0.68+.17	1.79+.72	0.68+

* Sample size: 5 tanks *(cajetes);* majority of tanks in series were partially filled so measuring was restric

All other averages drawn from measurements of 15 tanks in each field. Sample size determined by variat of Raunkiaer's (1934) sufficient sample method.

Traditional agroecosystem management

Soil and water conservation

Archaeological evidence indicates that the earliest settlements in the Tlaxcala area used sloping terraces in order to slow the rate of rainfall runoff and thereby soil erosion (Abascal and Garcia, 1975). There is evidence of canals in association with terraces dating from 1000 B.C., and this combination has evolved today into a sophisticated system of water and soil management. Channels divided into tanks, *(cajetes)* averaging 4.28 meters long with a regional average volume of 1.79 cubic meters per tank (Table 1), are excavated at the base of terrace walls and channel the field runoff during rains (Figure 1). Soil settles and is caught in the tanks while the water runs on through the series and eventually directed out of the cropp area. These *cajetes* serve a maintenan function by: 1) trapping eroded s which is later removed by hand and turned to the field; 2) catching wa which would normally not be absorb and allowing it to percolate slowly in the water table and 3) containing channelling rainfall and thereby pr tecting terraces below from uncontroll runoff.

In addition to these maintenan functions, *cajetes* also serve a develo mental role. When a farmer seeks to e pand production into a new area, t *cajetes* are built first to begin softeni the *tepetate* soil for cultivation and accumulate soil from upslope erosion addition to the new field. One half-h tare field which benefitted from run from an undeveloped slope above tra ped 30 to 40 cubic meters of new s during the five-month rainy season 1984.

While daily rainfall averages 5 mm is the maximum rainfall in a short peri of time which causes the most dama

Table 2. Calculations for catchment *(Cajete)* volume per hectare in Ixtacuixtla, Tlaxcala.

Length of maintained and abandoned cajete series on 11.02 ha hillside:	5366
Length in 1 hectare:	487
Cajete length as % of total length:	
Av. cajete length / Av. length + divider length	86.3
Net cajete length per hectare:	420
Average cajete depth:	0.59
Average cajete width:	0.68
Volume per hectare:	168.5

Figure 1. Series of catchment basins *(cajetes)* between terraced fields in Tlaxcala, Mexico.

and for which the system is designed. With an average *cajete* volume of 168.5 cubic meters per hectare (Table 2), the tanks can contain up to 16.85 mm of rainfall. This does not account for precipitation absorbed in the fields, or percolation out of the tanks. There were nine days between July 1 and September 28, 1984, in which rainfall exceeded 16.85 mm (SARH, 1984) and in only one downpour of 24.2 mm was the rainfall actually observed to exceed the current tank capacity.

The *cajete*/terrace complex, while managed by individual farmers, is dependent on the participation of all the farmers to insure that runoff from very large storms is channelled out of the crop area and does not damage neighboring fields.

Within the field the farmers can manage runoff by grading the slope of the furrows to minimize rapid runoff and erosion and yet avoid pooling of water around crop roots. The ideal slope adjustment for the local soil type ranged from 1.4 to 5.5 percent (measurements taken in the field with Suunto clinometer).

Agroecosystem diversity

Diversity is the second major characteristic of traditional agricultural management and involves the practices of intercropping, crop rotation and fallowing. In addition to these variations in crop management, diversity includes the effects of non-crop border species and patches of native vegetation. Mixed cropping systems have been shown to increase production and stability of an agroecosystem through the diversity of plant varieties grown together temporally or sequentially (Wilken, 1977, 1978; Chacon and Gliessman, 1980; Gliessman, 1981). The factors responsible for these benefits may include more efficient use of nutrient resources in the soil, more complete trapping of solar energy (Wilken, 1978), protection of the soil from wind and water erosion (Gerd Werner Fundacion, 1978), moisture retention in the soil, allelopathic inhibition of weed growth (Farrell, 1984), nitrogen fixation (Gliessman, 1981), and higher insect and disease resistance (Altieri and Letourneau, 1982). The actual mechanisms of these interactions require future study but the practice of mixed cropping is associated with sustained production in relatively closed traditional agroecosystems such as those found in Tlaxcala.

On an intensively cropped eleven hectare hillside in Tlaxcala, it was observed that the actual cropped area (managed by eight individuals) covered only 57 percent of the land area while fallow fields accounted for an additional 13 per-

cent (Table 3). The remaining 30 percent was permanent border space. In a sampling of individually managed parcels elsewhere in the region, the physical restrictions of terrace agriculture required 12 percent to 22 percent of the total area for terrace walls, *cajetes*, and field margins depending on the slope of the hillside. These border areas (Figure 2) insure the maintenance of regional plant diversity by providing a less intensively managed space for crop and non-crop species to grow. The long narrow orientation of the terraces, averaging 13 x 187 meters (Table 4), provides a greater spatial diversity for the field crops since no cultivar is more than 6.5 meters from border species.

These border species include maguey cactus *(Agave sp.)* for making local alcohol, fruit trees, and a variety of annuals, shrubs and trees which have economic and social value as food, medicine, fuelwood, and fodder. The ecological value of these border species as a whole has been examined (see citations above) but little is known about the effects of specific border species on the crops in the adjoining fields. Improvement of field soils in association with specific trees has recently been documented (Farrell, 1984).

Table 3. Land Use on 11 hectare hillside area near Ixtacuixtla, Tlaxcala.

	Transect	Percentage of Total Transect	Average Percentage of Area
—Cropped area:	#1	59.6	
	#2	65.1	57.4
	#3	47.7	
—Fallowed area:	#1	11.9	
	#2	6.0	13.1
	#3	21.5	
—Border:	#1	28.5	
	#2	29.0	29.5
	#3	30.8	

Data based on three 250 m transects across 14 terraces.

Crop diversity varies with microclimatic differences and with respect to proximity to transportation. Land area devoted to specific crops as a percentage of total area is given for the same traditionally managed 11 ha area and for state-wide rainfed land in Table 5. This information shows less intercropping and less variety in total crop species at the state level where monocropping is now more commonly practiced.

The role of native and introduced tr
species in the regional agroecosystem
vital to the maintenance of soil
sources. The extension of agriculture
the expense of native forests has expos
the soil to the erosive impact of dr
season winds and wet-season dow
pours. However, the preservation
trees along the field borders disrupts t
wind and stabilizes the terrace wal
Trees also circulate nutrients fro
deeper soil strata and through leaf litt
make it available to annual plants.

Diversity within individually ma

Figure 2. Cross section of field surfaces in Tlaxcala, Mexico showing terrace/catchment basin *(cajete)* complex.

aged fields occurs 1) in the relationship of border species to field crops and 2) within the cropping area through interplanting or adjoining patch variety. The diversity of non-crop annuals was found to be higher in established fields than in recently developed fields (35 and 23 respectively). The greater diversity in the more established fields can be explained by the fact that these fields provide more microhabitats due to the presence of both intermittently disturbed field areas and an undisturbed border area. In contrast, the more recently formed fields are composed only of disturbed habitats suitable to a lower diversity of early successional species. On more exposed ridge areas the degree of diversity in established and newer fields was less varied, suggesting that within the harsher conditions of the ridges successional development is not able to advance as far as on the borders of fields located in protected habitats. The limited microhabitat availability of the ridge is also reflected in less diversity of native perennials.

Diversity in crop species reflects the needs of subsistence farmers to meet the dietary needs of their families. The most common intercropping combination was corn/bean or corn/bean/squash *(Zea mays, Phaseolus vulgaris* and *Cucurbita pepo)* though other mixes were also sown. Even a patchwork of small monocrops has characteristics of diverse intercrops since several seed varieties of each crop are usually sown to insure success of at least one type in a region of climatic variability. Traditional seed selection further favors diversity by annually breeding for a complex of adaptive traits strengthened by the periodic introduction of seed from other regions.

Nutrient cycling

Traditional nutrient management emphasizes the maintenance of existing resources within the agroecosystem. Most food and crop by-products are used within the subsistence system and are returned to the fields in the form of manure or mulch. This, however, represents only part of traditional nutrient cycling and is concentrated on the fields closest to the community. Production on more remote fields is maintained through the mixed cropping of legumes with other crops and the introduction of forest leaf litter *(monte)*. Due to the scarcity of agricultural land, very little fallowing is practiced today except when crops fail because of diminishing soil nutrients. The unique functioning of the terrace/*cajete* complex in Tlaxcala adds another cycling process. The *cajetes* trap and concentrate nutrients along with the soil that is washed out of the fields by rains. In addition, they trap leaf litter from the border plants. This organic matter collects in the tanks and promotes additional non-crop growth along the field borders. The *cajetes* act as compost pits which are periodically emptied and distributed on the fields. While the farmers acknowledge that the total volume added in this way is not great, they stress the nutrient quality of this deposit. The traditional soil amendments all favor improved soil structure through the addition of organic matter which decreases the impact of wind erosion and increases the moisture, nutrient and cation retaining ability of the soil.

All of the traditional nutrient cycling methods as well as the soil conservation practices are based on labor intensive means of management. Human labor has historically been more available than other forms of energy or natural resources in Tlaxcala (until draft animals were introduced by the Spanish) so management strategies have evolved to make use of this labor potential.

Table 4. Terrace Size: Based on measurements taken in three distinct habitat/management complexes (meters) in Ixtacuixtla and Panotla municipalities, Tlaxcala.

Location	Average Width		Average length
1. Established slope, Multiple terraces owned by one farmer:	10.6*		90
2. Established slope; Single terrace owned by one farmer:	11.5*		350
3. Established ridge; Multiple terraces owned by one farmer:	18.0#		120
REGIONAL AVERAGE SIZE:	13.4+3.2	×	186.6+116

* Calculated from transects across a minimum of 10 terraces.
\# Measurements from single field chosen as representative of region (Less steep slope allows for wider fields).

Modern agroecosystem management

In contrast to the traditional management strategies, modern agricultural practices involve the introduction of fossil-fuel energy and synthetic chemical nutrients. 'Replacement' rather than 'maintenance' characterizes the major approach to continued agricultural production. Open flows of energy and inputs of nutrients involve economic trade at a global scale. Production decisions

Table 5. Crop diversity compared for local traditional management and statewide rainfed production in Tlaxcala, Mexico.

Crop	Local Traditional Management*	Statewide Rainfed Lands†
Maize *(Zea mays)*	33.5%	60.3%
Bush beans *(Phaseolus vulgaris)*	24.3%	1.1%
Oats/wheat *(Avena spp./Triticum aestivum)*	16.1%	6.3%
Barley *(Hordeum vulgare)*	9.8%	28.0%
Maize/squash *(Z. mays/Cucurbita pepo)*	9.3%	0
Maize/beans *(Z. mays/P. vulgaris)*	2.0%	0
Amaranth *(Amaranthus leucocarpus)*	1.8%	0
Fava Beans *(Vicia faba)*	1.7%	3.3%
Peas *(Pisum sativum)*	1.1%	0.1%
Squash *(C. pepo)*	0.3%	0
Potato *(Solanum tuberosum)*	0	0.8%

* Calculated from 3 transects across 14 terraces.
† Data for 1983 season from Secretaria de Agricultura y Recursos Hidraulicos (Farrell, 1984).

are based not only on local subsistence needs but on world market prices and national development policies. This section summarizes the impact of these changes as they affect the ecological functioning of this Tlaxcalan agroecosystem.

Soil and water reclamation

As agricultural expansion forces utilization of more marginal lands, farmers are forced to use *tepetate* soils exposed by previous poor soil management. The federal government has assisted in this reclamation by providing large earth moving machinery to break up the stone-like *tepetate* and form new terraces. The work is partially subsidized and requires a fraction of the time that hand preparation involved (days vs. years). The design of the terraces features an earthen burm at the outer edge to prevent washouts of the unstabilized soil. However, due to the poor percolation capacity of the soil, rainfall collects and flows out the ends of the fields. Since the new terraces lack *cajetes* to channel the flow of runoff, severe gully erosion quickly results in the loss of large areas of the cropping surface. In addition, the lack of *cajetes* means that these fields will require the replacement of nutrients and soil volume lost to erosion if production is to be sustained.

In the areas of older established fields there has been a more subtle change involving the gradual decline in the use or maintenance of *cajetes* over the last twenty years. The farmers attribute this decline to the rising cost of labor, but it also reflects other socioeconomic changes. Many farmers' children have moved to urban centers and the farmers themselves often work part time in local industry, further limiting time available for agricultural activities. Given the benefits of *cajetes* in the agroecosystem, the decline in their maintenance implies a loss in local nutrient cycling, a decrease in water holding capacity and percolation and an increase in erosion. Increasing fertilizer use to offset the loss of nutrients has occurred during this same twenty-year period.

Another introduced technology that impacts the management of soil and water is the use of small tractors to till hillside terraces. In order to enter the fields, the farmers fill in several *cajete* tanks and thereby interrupt the contiguity of the traditional water channeling system. The impact of this modification was observed to have drastic effects as uncontrolled water flowed over and through fields downslope, eroding soil, damaging crops, and flooding the streets of local communities. The use of tractors is not necessarily a problem; the disruption of traditional soil and water management systems is.

Declining diversity

Several changes have occurred which affect the plant diversity of the modern agroecosystem. Some farmers have enlarged the field size by removing a terrace and grading the adjoining fields together. This allows for the use of larger tractors but removes the *cajete*/border habitat which is an important source of local diversity.

Another trend involves the increasing production of single crops, usually corn or wheat *(Triticum aestivum)*, which has been encouraged by federal agricultural policies through local extension services. These programs stipulate that a farmer may not intercrop if he wishes to receive government agricultural assistance. The seeds provided in the assistance 'packet' are usually hybrids developed and tested in ideal growing conditions that do not approximate the local habitat or management practices. Standardization of crop characteristics makes the plants more vulnerable to climatic extremes and the spread of disease or insects that might wipe out an entire harvest. Traditional genetic variability insured production by at least some varieties or individual plants in a variety. The susceptibility of the less diverse agroecosystem is compensated for by the use of increasing amounts of other agricultural inputs such as pesticides and fertilizers. The result is an ecologically less stable and economically more open system.

Nutrient inputs

Most farmers today use synthetic chemical fertilizers on their crops as substitute or addition to animal m nures, cover cropping, and soil covered from *cajetes*. The significance this change is that the petroleum-bas fertilizer is produced outside of t agroecosystem and therefore can only obtained through exchange for cr products. This results in a great throughflow of energy in the system a a dependence on world petroleum pri fluctuations. Governmental agencies fer subsidized chemical fertilizers a advantageous credit terms.

While most farmers still distribu manure on home gardens and fields cated near the village, synthetic chem cal fertilizer is used almost exclusive on the remote plots where manure tran port would be more costly. Most farme report that fertilizer is more convenie to use than manure and that it nourish the plants quicker. Young farmers wi children too young to assist them wi manure transport were noted to u more fertilizer than older farmers w have working-age children. For a sma scale farmer, chemical fertilizer repr sents a smaller capital outlay than t purchase of more animals to produ manure. The production benefits combining chemical fertilizers with m nure have also been noted (Buchana 1983; Wolf, 1987).

Most farmers were very aware of so of the disadvantages of using fertiliz and often compared it with the virtu of manure. The most common comme (70 percent of farmers interviewed) w that fertilizer only lasted for one growi season whereas a manured field was pr ductive for three or four years. So farmers speculated about other cons quences of fertilizer use such as salt a cumulation, improper growth respon due to unbalanced fertilizer formu tions, and increased disease and ins problems. Further study is necessary substantiate these observations.

There is evidence that substituti chemical fertilizers for manure can a versely affect soil structure (Cox and A kins, 1979). The deterioration of crum structure that accompanies this shift due to the lack of organic polysaccha ides previously introduced in manu This trend reduces the water and n

trient retention capacity of the soil and can result in poor seed germination, desiccation of young plants, and the need to increase fertilizer application in order to maintain productivity. These results are probably not directly attributable to chemical fertilizer so much as to the lack of organic matter. Yet when both nutrient sources were used on the same field some farmers reported observing an antagonistic effect. Reduction in soil pH and associated reduction in availability of an important nutrient such as phosphorus could be attributed to the introduction of chemical fertilizer. Phosphorus is normally released from manure but can be chemically tied up by the higher soil acidity (Buchanan, 1983). Chemical fertilizers can also directly inhibit the functioning of soil microorganisms and mycorrhizae thereby reducing the efficiency with which nutrients are made available and taken up by plants (Powell and Bagyaraj, 1984; Johnson, et al., 1975). These interactions deserve further study since the use of chemical fertilizers along with manure in traditional agricultural systems has increased.

Implicit in the increase in fertilizer use is more involvement in the cash economy in order to pay for this input. The sale of crops for income increases the energy and nutrient outflow from the agroecosystem, which is compensated for by greater fertilizer inputs. Many farmers seek employment in local factories to gain a supplemental income. With less time to work on their land, they abandon soil conservation measures and use more fertilizer to maintain crop yields. In this cycle of escalating fertilizer use, traditional nutrient and labor inputs are partially replaced by purchased fertilizer from outside the agroecosystem. This replacement strategy, however, does not fully meet the ecological or economic needs of a long-term sustainable agroecosystem.

Conclusions

The model of closed versus open and traditional versus modern farming systems has been used in this article as a measure of change in a world of increasing global integration. It also allows us to locate 'leaks' in the cycling of resources since net losses make it increasingly expensive to sustain agricultural production.

The traditional systems of management on hills and slopes in Tlaxcala are based on the conservation of existing resources through intensive maintenance practices. Loss of soil, biomass or nutrients is not acceptable due to the limited availability of these resources on the slopes and due to the high cost of replacement with only human labor. The most distinctive feature in this region is the terrace and *cajete* complex for water and soil conservation. These structures have evolved in concert with the extension of agriculture into marginal environments and have a very long history of use. The long narrow fields that result from this approach to hillside cropping also create a diversified environment of crops in relation to border species. The purpose of studies such as this is to insure that the supplemental benefits of this complex do not go unnoticed in the transition to modern alternatives.

The decline in traditional management practices involves several factors operating at the state and national levels. Mexico's attempts to halt the flow of rural-urban migration has included the encouragement of factories in outlying regions such as Tlaxcala. The attractive wages offered by these employers has drawn farmers away from intensive agricultural management and has raised wages within the farm sector thus making traditional practices unaffordable. Agricultural extension programs have stipulated monocropping as a condition for receiving economic and technical assistance. Regional agricultural schools do not promote *cajetes* as a soil conservation technique but instead encourage terracing systems not as well suited to the local ecological conditions and usually constructed with heavy equipment. Government ceilings on crop prices and subsidized fertilizer further encourage the adoption of new technologies.

The open nature of nutrient cycling in modern management strategies reflects the availability and use of resources that originate outside of the farm-level agroecosystem and which are exchanged for products or labor from within the system. Heavy machinery replaces lost soil mass by reclaiming severely eroded regions; fertilizer replaces nutrients lost through soil erosion and the sale of the crop; and pesticides are introduced to compensate for reduced ecosystem diversity which had traditionally maintained resistance to infestation. Adoption of these modern strategies can involve a degradation of local ecosystem functioning and thus pose a threat to the sustainability of agricultural production unless modified and adapted to regional conditions..

We have pointed to some of the deleterious consequences of the modern management strategies, not with the intent of criticizing the government for introducing them, nor the farmers for adopting them, but to encourage further investigation of the impact of their long-term use. If there are long-term faults in these practices, then it falls to governmental agencies to reassess the value of such programs and to redesign them based on agroecological principles, so that the sustainability of food production can be assured.

This approach seeks to integrate the complex ecological principles of traditional agriculture with modern technological innovations that offer improved yields. For Tlaxcala this might include the construction of *cajetes* on tractor-built terraces, the provision of tractor access to fields without disrupting the functioning of the *cajete* system, maintenance of a diversified agricultural environment using a variety of improved seeds selected for local conditions, and encouragement and assistance for more investment in large or medium-sized domesticated animals as a source of manure. All of these integrations maintain relatively closed cycling of local resources while acknowledging the reality of the world economy and larger, more open systems of exchange.

Approaches that join traditional management practices with modern technological innovations can also meet Mexico's needs to improve rural living standards and reduce dependence on costly foreign technologies at a time of overwhelming debt. Agroecological solutions that draw on low-cost modern

technologies such as improved seed selection for rain-fed farming systems can raise rural incomes and allow greater investment in labor intensive soil conservation practices. Integrating the best of traditional and modern systems can provide economically and socially advantageous solutions for developing nations.

In developed countries, similar integrated approaches are needed to insure long-term production and economic viability of farming systems. This case study demonstrates principles that are applicable to most slope agriculture where soil and water conservation is essential. Cross-slope channels can trap eroded soil and replenish water tables. Border vegetation can introduce nutrients from deeper soil strata, reduce pest outbreaks and slow wind erosion. Modern farming strategies can employ these lessons from traditional agricultural systems and in the process gain greater ecological stability. In developed as well as developing agriculture, the choice of management strategies must ultimately be determined by the long-term sustainability of the agroecosystem.

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Minnesota develops alternatives program

With a windfall of funds from oil-overcharge restitutions, Minnesota's Department of Agriculture has established a Sustainable Agriculture Project. In cooperation with the state extension service, the Project has started on-farm demonstration/research plots on non-chemical weed management, and farm-produced nutrients and soil amendments.

"The project's strength lies in using farmers' expertise along with the specialists'," state leaders say. Cooperating farmers help plan the demonstrations, perform field operations, and document the management of each test plot. Farmers are also involved in a person-to-person public information effort. Concern about profitability and the threat of ground water contamination "has farmers looking for alternatives," says Project Coordinator Rick Gauger. "They've told us they want information that has been proven on farms by fellow farmers."

In addition to the on-farm demonstration, Minnesota's 1988 Omnibus Agriculture Act called for multiple innovations to reduce farm inputs and diversify the state's agriculture. These include recycling industrial by-products as soil amendments; a loan fund for conversion to sustainable agriculture methods; soil testing to check over-recommendation of fertilizers; promotion of integrated pest management; promotion of locally grown consumption of farm products; and establishment of an organic certification program.

Preferences for crop production practices among conventional and alternative farmers

Frederick H. Buttel and Gilbert W. Gillespie, Jr.

Abstract. *One of the major gaps in the empirical literature comparing conventional and organic farmers is the degree to which conventional farmers would prefer or can be motivated to use reduced-input practices comparable to those of alternative agriculturalists. This paper presents the results of a 1987 survey of a random sample of New York farm operators and a two-thirds sample of the membership list of the New York State chapter of the Natural Organic Farmers Association (NOFA-NY). The results show that while conventional farmers tend to have a lower preference for reduced-input practices than do alternative agriculturalists (NOFA-NY members), conventional farmers tend to prefer pest- and disease-resistant crop varieties, nonpurchased, on-farm-produced sources of fertility, and nonchemical means of disease control over high-input, chemically-based production practices. The largest differences between conventional and alternative agriculturalists are with respect to preferences for weed control practices. For six of the eight practices assessed, operators of small farms (annual gross sales less than $40,000) were intermediate in their preferences between commercial-scale farmers (gross sales $40,000 or more) and alternative agriculturalists. There was, however, virtually no difference between conventional and organic farmers in their tillage practice preferences; similar percentages of the NOFA members and commercial-scale farmers preferred minimum tillage practices, while the percentage of small farmers preferring to use as few tillage operations as possible was lower than that of both commercial-scale and organic farmers. Differences between conventional and organic farmers in their production practice preferences are far smaller than differences in their environmental orientations.*

Key words: New York farmers, conventional, organic, reduced input practices, pest resistance, disease resistance, tillage practices.

Introduction

One of the most thoroughly studied areas in alternative agriculture is that of socioeconomic, attitudinal, and agronomic practice differences between conventional and alternative agriculturalists (see, for example, Berardi, 1978; Foster and Miley, 1983; Pimentel et al., 1983; Harris et al., 1980; Lockeretz et al., 1981). Several researchers, however, have suggested that there are major limitations to these comparison studies. Lockeretz (1985), for example, has stressed that on-farm comparison studies can address only a limited range of biological-agronomic issues in alternative agriculture or agroecosystems research. Buttel et al. (1986) have suggested that the traditional conventional-organic distinction ignores the fact that there are a number of "conventional" farmers (i.e., those who do not identify themselves as "organic" or "alternative" agriculturalists) whose practices and technical needs have broad similarities to their organic or alternative agriculturalist colleagues.

Comparable arguments have been made by other researchers (Lockeretz and Wernick, 1980; Dalecki and Bealer, 1984), who claim that organic farmers and farming operations often have considerable similarities with conventional ones when size of farm is controlled. Here we wish to begin to explore a related notion - that one of the critical issues in the future of alternative agriculture concerns the degree to which otherwise conventional farmers would prefer, or can be motivated to prefer, "alternative" or "low-input" practices such as nonchemical means of pest control, disease control, and fertility.

In this paper, we will examine the responses of a random sample of New York State farm operators and comparable responses from a two-thirds sample of the New York State chapter of the Natural Organic Farmers Association (NOFA-NY) to a winter 1987 survey that included a set of questions about preferred production practices. The preferences for low- or reduced-input production practices of NOFA-NY respondents will be compared to those of two size categories of conventional farmers. Finally, we will examine the relationships between type of farm operator/operation and crop production practice preferences with comparable data on the relationships between type of farm and agricultural-environmental concern orientations.

Methods

The data for this study were collected from two samples of New York farm operators in the late winter and early spring of 1987. The first was a random sample of 599 New York farm operators from the list maintained by the New York State Crop Reporting Service. The second was the NOFA-NY membership list. For the NOFA-NY list, all addresses judged likely to be nonfarm were

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culled out, and two out of three of the remaining addresses were randomly selected. The response rates, adjusted for those who said they had not been a farm operator since 1982 and for inaccurate addresses, were 57.8 percent for the general sample and 69.9 percent for the NOFA-NY sample. Although the general sample of New York farm operators did include one name on the NOFA-NY list (which was excluded from the NOFA sample), we consider the general sample to be one of "conventional farmers."

Identical 18-page questionnaires were sent to all addresses on the lists for the two samples. Following the Dillman (1978) method, respondents were contacted up to four times - first with a cover letter explaining the survey and a copy of the questionnaire, one week later with a postcard reminder, and, if necessary, with two additional mailings - until a completed questionnaire was received. Farm size was measured by a direct question asking for the operator's gross farm income the previous year (1986). For this study, small farm operators are considered to be those whose 1986 gross farm sales were less than $40,000, and commercial-scale farm operators are defined as those whose gross farm sales were $40,000 or more.

The recipients of the mail survey questionnaires were asked to respond to a series of questions about their preferences for crop production practices (the exact wording of which appears in Appendix A). These questions were preceded by the following introductory statement:

> Some farmers have reported that even though they use a particular production practice, they would prefer to get along without this practice. Use of certain chemicals for insect control or for weed control have been examples. Little is known, however, about farmers' preferences for crop production practices. *For each of the following questions, assume that both practices described would yield about the same net profit* (emphasis in original).

Thus, the farmer respondents were asked to indicate the types of production practices they prefer, irrespective of their current practices or of profitability considerations.

Table 1. Percentage Distributions of Preferences for Crop Production Practices by Type of Farm.

Phase of Crop Production*	Percent By Type of Farm**			
	Conventional			
	Small	Commercial	All	Orga
Varietal Selection				
Prefer moderate-yield, low-input varieties	87.1	83.4	85.6	97.
No preference	10.6	6.6	8.3	2.
Prefer high-yield, high-input varieties	2.3	9.9	6.7	0.
Ns	(132)	(181)	(313)	(7
Fertility				
Prefer on-farm sources	66.2	65.6	65.8	100.
No preference	12.8	13.9	13.4	0.
Prefer purchased fertilizers	21.1	20.6	20.8	0.
Ns	(133)	(180)	(313)	(7
Weed Control				
Prefer cultural practices	59.1	35.5	45.4	98.
No preference	10.6	13.1	12.1	1.
Prefer commercial herbicides	30.3	51.4	42.6	0.
Ns	(132)	(183)	(315)	(7
Insect Control				
Prefer natural controls	47.0	42.3	44.3	100.
No preference	20.5	26.4	23.9	0.
Prefer commercial insecticides	32.6	31.3	31.8	0.
Ns	(132)	(182)	(314)	(7
Disease Control				
Prefer natural controls	73.1	75.3	74.4	98.
No preference	9.0	11.0	10.1	0.
Prefer commercial fungicides	17.9	13.7	15.5	1.
Ns	(134)	(182)	(316)	(7
Tillage System				
Prefer as few as possible	33.6	44.5	39.8	48.
No preference	12.7	9.9	11.1	7.
Prefer as many tillage operations as necessary	53.7	45.6	49.1	44.
Ns	(134)	(182)	(316)	(7
Crop Mix				
Prefer crop rotations	58.3	44.0	50.0	88.
No preference	12.1	7.7	9.6	4.
Prefer to specialize	29.5	48.4	40.4	7.
Ns	(132)	(182)	(314)	(7
Crop Production Management				
Prefer low purchased inputs, high labor	41.2	21.9	36.6	78.
No preference	31.3	34.8	33.3	20.
Prefer high purchased inputs, low labor	27.5	43.3	30.1	1.
Ns	(131)	(178)	(309)	(7

*See Appendix A for the exact wording of questions and responses. The responses presented in this ta are paraphrases of the actual response categories.

**For each practice and type of farm, the three column percentages sum to 100.0, except for roundi errors. The total N is 398.

A scale measuring farmer preferen for reduced-input practices, which cluded all of the crop production pr

erence items except for the tillage system item, was constructed by summing each respondent's scores for all the items. The tillage preference item was omitted for two reasons: First, the meaning of this item is theoretically ambiguous in the context of such a scale; while production systems using reduced tillage are typically associated with reduced soil erosion and possibly reduced energy usage, they also tend to require use of herbicides and often insecticides as well. Second, subsequent analysis (not reported here) determined that the tillage system item has very low - and, in some cases, negative - correlations with the other production practice preference items. The resulting seven-item scale had a Cronbach's alpha coefficient of 0.69, indicating substantial internal reliability.

The four agricultural-environmental concern items were all Likert-type items to which respondents were asked to indicate their extent of agreement or disagreement on a five-point scale that included alternatives ranging from strongly agree to strongly disagree. The exact wording of the items appears in Table 3. In addition, a scale of farmer agricultural-environmental concern was constructed from the four items. Since three of the four items were phrased in an anti-environmental direction, these three items were reverse scored so that respondents with high levels of agricultural-environmental concern were assigned high scores. In order that the three main areas of agricultural-environmental concern - soil erosion, pesticide use, and nitrate fertilizer pollution - would be represented equally, scores for the two items pertaining to nitrate fertilizer pollution were averaged for each respondent and the average score on these two items was summed with those of the two other items. The resulting scale had an alpha coefficient of 0.72.

For the analysis, two sets of dichotomous independent variables were compared: operators of small farms versus operators of commercial-scale farms, and conventional versus organic farmers. The Mann-Whitney U, a nonparametric test of whether the two groups being compared come from the same population, was computed for the relationships between each of the dependent variables and the two independent variables. If the two groups being compared on a dependent variable have a low probability of coming from the same population, we will conclude that the groups differ on that variable.

Results

Crop production practice preferences

Table 1 reports the percentage distributions for the eight crop production practice preference items among the four groups of farmers (small versus commercial-scale conventional farmers; all conventional farmers versus alternative-organic [NOFA-NY] farmers). One of the most striking features of Table 1 is that while conventional farmers generally tend to have a lower preference for low-input practices than do alternative-organic farmers, the differences are in many cases very modest. In particular, conventional farm operators have a strong tendency to prefer pest- and disease-resistant crop varieties, the use of nonpurchased, on-farm-produced sources of fertility, and use of nonchemical means of disease control.

For example, Table 1 shows only modest differences in the percentage distributions among the four groups of farmers in their preferences for crop varieties. Strikingly large percentages of small and commercial-scale conventional farmers (87.1 and 83.4 percent, respectively) expressed a preference for moderate-yield crop varieties for which the use of chemical fertilizers and pesticides would seldom be needed. The organic farmer sample was somewhat more likely (97.1 percent) to prefer low-input crop varieties over higher-yielding, higher-input varieties than were conventional farmers (85.6 percent).

Table 2 reports summary statistics for the Mann-Whitney tests of the relationships between the independent variables and each of the production practice dependent variables. Table 2 shows that while there was no significant difference between small and commercial-scale farmers in their crop variety preferences, the organic farmers were significantly more likely to prefer low-input varieties over higher-input, high-yield varieties than were the conventional farmers.

While differences between conventional and organic farmers in their preferences for fertility sources were somewhat larger than with the crop varieties item, a similar pattern was revealed. Major proportions of both small (66.2) and commercial-scale (65.6) farmers expressed a preference for animal manures, plowed-down legumes or cover crops, and other on-farm-produced, nonchemical sources over chemical sources of soil fertility (see Table 1). By contrast, 100 percent of the organic farmers preferred nonchemical means of providing soil fertility over NPK mix-

Table 2. Mann-Whitney Analysis of Relationships Between Selected Types of Farms and Preferences for Crop Production Practices.

	Type of Farm Compared			
	Small vs. Commercial		Conventional vs. Organic	
Attitudinal Item*	Higher rank**	p-value+	Higher rank**	p-value+
Varietal Selection	Small	.131	Organic	.003
Fertility	Small	.478	Organic	.000
Weed Control	Small	.000	Organic	000
Insect Control	Small	.344	Organic	.000
Disease Control	Commercial	.284	Organic	.000
Tillage System	Commercial	.040	Organic	.145
Crop Mix	Small	.001	Organic	.000
Crop Production Management	Small	.000	Organic	.000
Reduced-Input Preference Scale***	Small	.000	Organic	.000

* See Appendix A for exact wording of items. High scores or ranks reflect preferences for low-input practices.

** Category listed has the higher mean rank.

*** Summated scale derived from seven of the preceding items. See text for measurement procedures.

\+ One-tailed test of significance corrected for ties.

tures, anhydrous ammonia, and so on. Table 2 shows that organic farmers were significantly more likely than the conventional farmers to prefer on-farm-produced, nonchemical sources of fertilization.

The data for weed control practice preferences showed significant differences between both small and commercial-scale farm operators and conventional and alternative-organic farmers. While nearly all (98.6 percent) of the organic farmers preferred mechanical cultivation, crop rotations, overseeding of cover crops, and other nonchemical weed control practices over use of herbicides, 59.1 percent of small farmers and only 35.5 percent of commercial-scale farmers did so (see Table 1). Table 2 shows that farmers with small farms differed significantly from those with commercial-scale farms and that conventional farmers differed significantly from organic farmers in their preferences for weed control practices.

Fully 100.0 percent of the NOFA-NY respondents were found to prefer insect control measures such as insect traps, plant-derived insecticides, introduction of beneficial insects, and comparable practices over use of commercial insecticides such as Sevin, compared to 47.0 percent of the farmers with small farms and 42.3 percent of those with commercial-scale farms (Table 1). While the difference between operators of small and large farms was not statistically significant, there was a strong, statistically-significant difference between respondents using conventional practices and those using organic practices (Table 2).

With respect to disease-control practices, respondents with small and commercial-scale farms exhibited similarly strong preferences for crop rotations, adjustment of planting times, and use of disease-resistant varieties over use of commercial fungicides. Roughly three-quarters of operators of small and commercial-scale conventional farms preferred these low-input, nonchemical means of disease control. Producers using alternative-organic practices, however, were virtually unanimous in their preferences for nonchemical control of plant diseases (98.6 percent). Table 2 indicates that the alternative-organic respondents differed significantly from the respondents using conventional practices, while the difference between operators of small and commercial-scale farms was not significant.

Unlike the previously-discussed items, each of the four categories of farmers exhibited relatively similar percentage distributions preferring "as many tillage operations as necessary to make a smooth seedbed and control weeds" and "use as few tillage operations as possible" (Table 1). Respondents with small farms, however, tended to be less likely to prefer reduced-tillage systems than were commercial-scale conventional farmers, and this difference is statistically significant at the .04 level (Table 2). Respondents with small conventional farms were also more likely than operators of alternative-organic farms to p fer reduced tillage. Operators alternative-organic farms and of co mercial-scale conventional farms very similar tillage system preferenc The finding that the percentage of ternative-organic farmers preferring duced tillage was quite similar to t of commercial-scale conventional fa ers is not highly surprising in that ma organic farmers will be reluctant to reduced-tillage practices because th practices tend to require use of her cides. This finding is also consistent w previous research indicating that duced-tillage practices have tended to adopted more for their labor-saving vantages than for their potential for ducing soil erosion (see Buttel a Swanson, 1986).

Table 3. Percentage Distributions of Selected Agricultural-Environmental Orientations by Type of Far

Phase of Crop Production*	Percent, By Type of Farm**			
	Conventional			
	Small	Commercial	All	Orga
Soil erosion is one of the major threats to the future of American agriculture.				
Strongly disagree	2.9	1.6	4.0	0.
Mostly disagree	17.5	27.3	28.7	0.
Neutral/uncertain	18.2	27.3	35.2	7.
Mostly agree	46.7	38.0	24.4	49.
Strongly agree	14.6	5.9	7.4	43.
Ns	(137)	(187)	(324)	(7
The pollution effects of nitrate fertilizers are quite unimportant compared to all their benefits.				
Strongly disagree	13.9	9.6	11.4	70.
Mostly disagree	31.4	19.1	24.3	25.
Neutral/uncertain	32.1	43.1	38.5	4.
Mostly agree	19.7	24.5	22.5	0.
Strongly agree	2.9	3.7	3.4	0.
Ns	(137)	(187)	(325)	(7
There is too much talk about all the harmful effects of pesticides and not enough about their benefits.				
Strongly disagree	9.4	5.3	7.1	80.
Mostly disagree	29.0	17.0	22.1	15.
Neutral/uncertain	21.7	22.3	22.1	4.
Mostly agree	31.2	44.7	39.0	0.
Strongly agree	8.7	10.6	9.8	0.
Ns	(138)	(188)	(326)	(7
Environmentalists have greatly exaggerated the dangers of nitrate fertilizer pollution				
Strongly disagree	5.8	5.9	5.8	70.
Mostly disagree	22.5	9.6	15.0	25.
Neutral/uncertain	42.0	44.1	43.3	4.
Mostly agree	21.7	33.5	28.5	0.
Strongly agree	8.0	6.9	7.4	0.
Ns	(138)	(188)	(326)	(7

*For each item and type of farm, column percentages total to 100.0, except for rounding errors.

Table 1 shows that the four categories of farmers exhibit substantial differences in their preferences for crop rotations versus crop specialization. Nearly 90 percent of alternative-organic respondents preferred producing several crops in a system of regular crop rotations, while 58.3 percent of operators of small farms and 44.0 percent of operators of commercial-scale farms shared this preference. Table 2 shows that there were statistically significant differences in crop mix preferences between respondents with small and commercial-scale farms and between respondents using conventional versus organic practices.

Among the largest differences among the four groups of farmers was with regard to general crop production management practices. Table 1 shows that few respondents with commercial-scale conventional farms (21.9 percent) preferred practices that use low amounts of purchased inputs and large amounts of labor for managing crop production problems such as weed and insect control; by comparison, 41.2 percent of operators of small conventional farms and 78.6 percent of alternative-organic farm operators indicated such a preference. Likewise, few respondents (1.4 percent) using alternative-organic practices preferred production systems in which large amounts of purchased inputs and small amounts of labor are used, compared to 27.5 percent of small farm operators and 43.3 percent of commercial-scale conventional farms. Differences between operators of small and commercial-scale conventional farms and between respondents using conventional and alternative-organic practices were both statistically significant (Table 2). It should also be noted that the crop production management item elicited large proportions of "no preference" responses, particularly among the conventional farm operators, perhaps indicating an openness to low-input practices.

The final step in the analysis was to analyze differences among the two sets of groups with respect to the summated scale that was designed to measure overall preferences for reduced-input, alternative practices. Table 2 shows that respondents with small farms had a significantly stronger preference for reduced-input, alternative practices than did those with commercial-scale farms. Similarly, respondents with alternative-organic farms had a significantly stronger preference in this direction than did those with conventional farms.

Table 4. Mann-Whitney Analysis of Relationships Between Selected Types of Farms and Agricultural-Environmental Orientations.

	Type of Farm Compared			
	Small vs. Commercial		Conventional vs. Organic	
Attitudinal Item	Higher rank*	p-value+	Higher rank*	p-value+
Soil erosion is one of the major threats to the future of American agriculture.	Small	.001	Organic	.000
The pollution effects of nitrate fertilizers are quite unimportant compared to all their benefits.**	Commercial	.006	Conventional	.000
There is too much talk about all the harmful effects of pesticides and not enough about their benefits.**	Commercial	.001	Conventional	.000
Environmentalists have greatly exaggerated the dangers of nitrate fertilizer pollution.**	Commercial	.008	Conventional	.000
Agricultural-environmental concern scale***	Small	.000	Organic	.000

* Category listed has the higher mean rank.
** Because these items are stated in an anti-environmental direction, high scores reflect a low level of environmental concern.
*** Summated scale derived from the four preceding items. See text for measurement procedures.
+ One-tailed test of significance corrected for ties.

Agricultural-environmental orientations

Table 3 reports percentage distributions for the four categories of respondents for four attitudinal items and a summated scale measuring agricultural-environmental orientations. Table 3 shows that respondents with small farms tend to be more likely to express concern for the quality of the agricultural environment than do operators of commercial-scale farms. There are even larger differences in agricultural-environmental orientations between operators of conventional and alternative-organic farms, with operators of alternative-organic farms having strikingly more pro-environmental attitudes than either small or commercial-scale conventional farm operators. Table 4, which reports Mann-Whitney test statistics for these relationships, corroborates the results of Table 3 and shows that each of the differences is statistically significant.

It should be stressed, however, that the differences in agricultural-environmental orientations between alternative-organic and conventional farmers are far larger than those observed with respect to crop production practice preferences. Thus, it appears that conventional farmers' motivations in identifying preferences for production practices are to a considerable degree independent of their environmental orientations.

Summary

The results of this study suggest the need to move beyond simple conventional-organic farmer comparisons and to explore further the antecedents of the use of low-input production practices among conventional farmers. The data of this study, though confined to the level of production practice preferences, suggest very strongly that there may be great untapped potential for agricultural researchers and policy-makers to increase the ability of the vast rank-and-file of nonorganic farmers to employ resource-conserving, more environmentally-sound, reduced-input practices. In particular, the conventional farmers in our study appear to have unexpectedly strong preferences for many low-input practices despite the fact that these farmers tend to have relatively little concern about the environmental consequences of current farm practices - phenomena that represent a much more important consideration among organic farmers. In

general, operators of small conventional farms were more similar in their crop production practice preferences to alternative-organic farmers than were operators of commercial-scale conventional farms, though farm size differences in production practice preferences among conventional farmers were quite variable and, in four cases, were not statistically significant.

One might speculate that there is even further untapped potential for interest in low-input practices among conventional farmers than is revealed in our data when one considers the reality that environmental control or regulation will tend to be in the economic interest of farmers. It has long been recognized that environmental regulation of agriculture, by reducing chemical input usage substantially and decreasing yields to a moderate degree, would tend to result in a disproportionate increase in agricultural product prices and in higher returns to farmers (see, for example, Olsen et al., 1982).[1] To the degree that conventional farmers come to recognize that they will tend to benefit from environmental control in agriculture, they may increasingly come to prefer low-input alternatives to conventional chemically-based production practices.

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APPENDIX A. MEASUREMENT OF PREFERENCES FO CROP PRODUCTION PRACTICES

In selecting crop varieties, which of the following would you prefer? (Circle the numb of the *one* answer that most closely reflects your opinion.)

1. A variety with very high yield potential, but which requires heavy use of fertiliz and pesticides to get high yields.
2. A variety with a moderate yield potential, but which is resistant to pests a diseases so that chemicals are seldom needed.
3. Have no preference.

For fertilizing your crops, which of the following would you prefer to rely on as yo *main* source of soil fertility? (Circle the number of the *one* answer that most clos reflects your opinion.)

1. Animal manures, plowed-down legume or cover crops, and other sources of fertil that you produce on your farm.
2. Purchased fertilizers such as NPK mixtures and anhydrous ammonia.
3. Have no preference.

For controlling weeds, which of the following would you prefer to use as your *prim* means? (Circle the number of the *one* answer that most closely reflects your opinio

1. Commercial herbicides, such as 2, 4-D or Roundup.
2. Cultivation, crop rotations, overseeding of cover crops, and other cultural practic
3. Have no preference.

For controlling insect pests, which of the following would you prefer to use? (Cir the number of the *one* answer that most closely reflects your opinion.)

1. Commercial insecticides, such as Sevin.
2. Measures such as insect traps, timing your plantings to reduce pest outbrea plant-derived insecticides, and introducing beneficial insects that prey on ins pests.
3. Have no preference.

For controlling crop diseases, which of the following would you prefer to use? (Cir the number of the *one* answer that most closely reflects your opinion.)

1. Commercial fungicides.
2. Measures such as crop rotations, changing planting times, or using disease-resist varieties.
3. Have no preference.

[1]This finding, of course, assumes that environmental regulation of agriculture is general and national, rather than local, in scope. It is likely the case that conventional farmers tend to oppose environmental regulation because regulation is usually local in scope, thus causing farmers to not be in a position to benefit from the macroeconomic effects of reduced output.

In selecting a tillage system, which of the following would you prefer? (Circle the number of the *one* answer that most closely reflects your opinion.)

1. To use as many tillage operations as necessary to make a smooth seedbed and to control weeds.
2. To use as few tillage operations as possible (such as no-till or conservation tillage).
3. Have no preference.

When selecting the mix of crops for your farm, which of the following would you prefer? (Circle the number of the *one* answer that most closely reflects your opinion.)

1. To produce several crops using a system of regular crop rotations.
2. To specialize in one or two crops.
3. Have no preference.

For managing crop production problems such as weeds and insects, which of the following would you prefer? (Circle the number of the *one* answer that most closely reflects your opinion.)

1. Systems requiring large expenditures for purchased products, but which use little labor.
2. Systems using much labor, but which require small expenditures for purchased products.
3. Have no preference.

Keeney named Director of Iowa's Leopold Center

Dennis Keeney, Professor of Soil Science at the University of Wisconsin and President of the Soil Science Society of America, has been named first Director of the Leopold Center for Sustainable Agriculture at Iowa State University. The Center was created by the 1987 Iowa Groundwater Protection Act and given the mission to develop farming systems that combine natural resource stewardship with farm profitability. Keeney has devoted "an entire career to the interface between production agriculture and the environment," said Interim Director Robert Jolly.

FROM THE LITERATURE

Abstracted by William Lockeretz

Research Reports

Interaction of methyl parathion with permethrin and flucythrinate as related to their mutual persistence in soil. S. Smith and G. H. Willis. *Soil Science* 144(1):67-71 (1987).

Because of insect resistance to insecticides, in cotton production it is common to use an organophosphate against the boll weevil along with a pyrethroid (synthetic analogue of the natural insecticide pyrethrin) against the bollworm and tobacco budworm. Choosing a combination solely on the basis of which ones control which pests ignores interactions between insecticides that can increase or decrease their persistence in the soil. If an insecticide lasts longer than expected, this could increase its effectiveness, but it could also increase contamination of the environment and harm beneficial species that control pests. Both increased and decreased persistence have been reported when insecticides are applied in combination. It is thought that this occurs because one insecticide either inhibits or enhances the enzymes in soil microbes that break down the other insecticide.

This study used gas chromatography to measure the insecticides remaining in soils after an incubation of 1, 3 or 6 weeks. Methyl parathion, an organophosphate, was applied with either permethrin or flucythrinate, both of which are pyrethroids. The three individual insecticides were also applied alone. All five of these insecticide treatments were applied with and without application of cotton plant residues.

Flucythrinate retarded the disappearance of methyl parathion regardless of whether plant residues were present, but permethrin had no effect. For example, after a six-week incubation, twice as much methyl parathion (about 31 percent of the original application) remained when flucythrinate was also applied compared to methyl parathion alone or with permethrin. However, methyl parathion speeded the disappearance of permethrin, both with and without residues. Finally, methyl parathion had no effect on the disappearance of flucythrinate. The authors suggest that changes in persistence of one insecticide in the presence of another be taken into account when combinations are recommended.

Ecological effects of organic agricultural practices on insect populations. Thomas W. Culliney and David Pimentel. *Agriculture, Ecosystems and Environment* 15:253-266 (1986).

This study examined how four fertilizer treatments affected the density of insect pests on collards. Treatments were municipal sewage sludge or cow manure at 100 dry tons/acre, or 700 lbs/acre of commercial 13-13-13 fertilizer, or no fertilizer. Insect population monitored weekly during the growing season included adult flea bee-

tles (Phyllotreta spp.), lepidopteran larvae (e.g., imported cabbageworm, cabbage looper), and aphids (e.g., cabbage aphid, green peach aphid).

Crop growth varied strongly with fertilizer treatment, in the order sludge manure > chemical fertilizer > untreated. The populations of the various insects showed a complex dependence on time. In mid-season, flea beetles were least common with sludge but increased later, whereas their populations decreased in late season with the other treatments. Lepidopteran larvae tended to be higher with no treatment than with sludge or manure in late season, and were higher with chemical fertilizer than with sludge or manure in the final week. Towards the end of the season, aphids were most common with no treatment, but fell at the very end to become comparable to chemical fertilizer and manure.

Leaf nitrogen content was highest with sludge, intermediate with manure, and lowest with chemical fertilizer and no treatment. A higher plant nitrogen level is known to increase the population of several insect species, but the authors noted that a "balanced" mix of nutrients has been reported to reduce certain pest populations. They interpret their results as supporting this view, "assuming that the sludge and manure treatments...provided a more favorable balance of nutrients for collards than was the case in both the commercial fertilizer-treated and the untreated plots." However, the nutrient contents of the sludge and manure were not reported, and the only nutrient analysis for the plant was for N. Soil analyses were reported for N, P, K, Mg, and Ca, but the desirable ratios among these nutrients for collards were not stated, so that it is not clear whether the assumption of "balanced" nutrients was fulfilled.

Another possible explanation of the results is that there were differences in the concentrations of allelochemicals under different treatments, which would make the plants more or less attractive to various insects. Also, the plants grown with sludge or manure were larger and had a more closed canopy, which could affect the microclimate and in turn influence the distribution of insect pests and their enemies. Finally, the sludge and manure treated plots attracted more birds, which may have helped control lepidopteran larvae.

Reviews and analyses

The role of white clover in United Kingdom pastures. John Frame. *Outlook on Agriculture* 16(1):28-34 (1987).

White clover traditionally has been included with grass in pastures in the United Kingdom. A clover/grass mixture is nutritionally superior to grass alone. Moreover, its nitrogen value is considerable: to get the same dry matter production as a grass/clover mixture with no added N, grass alone would have to receive an average of 180 kg N/ha. However, the importance of clover has declined, especially among dairy farmers. A main cause has been heavy fertilization of pastures with synthetic N at rates up to 400 kg/ha (360 lb/acre). With synthetic N readily available, farmers either do not try or no longer know how to maintain an adequate proportion in the pasture.

Relevant management factors include the choice of white clover cultivar, method and timing of establishment, compatibility with various grasses, N application rate, soil fertility, use of pesticides, and frequency and method of harvesting. New cultivars offer substantial improvements over those in common use, but seed yield has been too erratic for an adequate seed production industry to have developed. Early, shallow sowing has been found to give the most satisfactory establishment. Farmers generally choose the pasture grass that is most productive in its own right, even though it may suppress the proportion of clover. High N applications favor grass over clover. Clover is more sensitive than grass to soil nutrient status, so that its proportion drops with low pH or inadequate P or K. Choice of herbicides and timing of applications are critical, since clover is killed by most broadleaf herbicides. Clover is fa vored if the pasture is cut at least onc instead of only being grazed, or if graz ing is rotational instead of continuou

Low input white clover/grass sy tems have been shown to be an ecc nomical alternative to grass-based bee production systems fertilized heavil with N, and clover could play a muc greater role under a wide range of ci cumstances. Further educational wor is needed to keep beef and sheep pro ducers from giving clover up altogethe and following United Kingdom dair farmers, who "continue to worship a the altar of fertilizer N."

Farmworkers and farm chemicals: EPA sets new rules

In rules published June 29, 1988 the Environmental Protection Agency has drawn up new measures to protect farmworkers from acci dental poisoning by farm chemicals More than 50 chemicals are added to the list of 12 most-toxic pesticides to which the rules apply. The pro tections will extend to workers in forests, nurseries, and greenhouses as well as on farms. Pesticide han dlers will be required to wear res pirators, gloves, and aprons in addition to the usual protective clothing, and training will be re quired for reentry workers.

The rules update 1972 regulations which have been widely regarded as insufficient to protect farmworkers against pesticide poisonings. The EPA estimates such poisonings to be in the thousands every year, with effects that range from sudden vom iting and breathing difficulties to long-term dangers of cancer and birth defects. Reaction to the rule is varied. Farmworker organiza tions think they do not go far enough, while grower groups ex press some concern about the cos of implementation, reports *The Washington Post.*

Weed seed destruction by arthropods and rodents in low-input soybean agroecosystems

Gerald E. Brust and Garfield J. House

Abstract. *Weed seed consumption experiments involving comparison of rates of seed loss by seed feeders were conducted over a five-week period in low-input (no insecticide, low herbicide usage) conventional- and no-tillage soybean agroecosystems. Seeds of four broadleaf weed species (ragweed [*Ambrosia artemisiifolia *L.], pigweed [*Amaranthus retroflexus *L.], sicklepod [*Cassia obtusifolia *L.], and jimsonweed [*Datura stramonium *L.]) and one grain crop species (wheat [*Triticum aestivum *L.]) were provided in a free choice design at densities of 10, 25, and 50 seeds/24 cm^3. Approximately 2.3 times more seeds overall, and 1.4 times more large seeds as a group were consumed in no-tillage systems than in conventional-tillage systems. In our experimental low-input, no-tillage treatments, large ground beetles (Carabidae: Coleoptera) (15-25 mm) and mice preferentially fed on the larger seed species, while small carabids (< 15 mm), ants and crickets, fed almost exclusively on the smaller seed species. Carabid beetles were responsible for more than half of all seeds consumed. Laboratory and field studies indicated that ground beetles selectively consumed specific seed species. In conventional-tillage, ants were one of the dominant consumers of seeds, suggesting different patterns of resource partitioning in each tillage system. We suggest that selective feeding by arthropod seed feeders, in combination with their high number, could affect the species composition and possibly the abundance of weeds in low-input, no-tillage agroecosystems.*

Key words: ants, beetles, mice, selective seed eating, conventional tillage, no-till, no insecticide, minimal herbicide

Introduction

Environmental concerns stemming from an inadequate understanding of the fate of herbicides commonly used in no-tillage and other conservation-tillage systems (Hinkle, 1983), as well as from economic considerations (Buttel et al., 1986; Domanico et al., 1986), have renewed research interest in the biological control of weeds. Although several studies have examined seed consumption by soil-inhabiting organisms in different ecological systems, such as tropical ecosystems (Carroll and Risch, 1984; Horvitz and Beattie, 1980; Janzen, 1971) and desert ecosystems (Abramsky, 1983; Brown et al., 1975; Davidson, 1977; Mehlhop and Scott, 1983; Price, 1978), seed destruction as a mechanism of biological control in cropping systems has received little attention.

In a few studies, investigations have examined seed feeding in temperate old-fields and pastures (Mittelbach and Gross, 1984), however, even fewer studies have been conducted in any type of row crop system (Risch and Carroll, 1986). Thus, except for laboratory studies on seed consumption by carabids (Lund and Turpin, 1977) and the observation of seed caching by carabid larvae (Kirk, 1972), little is known about the impact of seed feeders in agroecosystems. In the majority of studies, either ants, or ants in combination with rodents, were the major seed predators, removing a large enough number of seeds in some studies to alter the distribution and abundance of plant species (Brown et al., 1975; Janzen, 1971).

Low-input, no-tillage agroecosystems (e.g., those without insecticides or soil disturbance for periods of at least 4 to 5 years) possess characteristics similar to those occurring in natural or less disturbed systems, such as old fields and prairies (House et al., 1984). Nutrient cycling patterns, soil litter accumulation and decay, and soil faunal communities in low-input systems resemble natural systems to a greater degree than in conventional-tillage systems which are subjected to regular and periodic amendments and soil perturbations. Low-input, no-tillage systems also typically generate different weed species compositions than those of conventional-tillage systems (Triplett and Worsham, 1986). No-tillage practices involving a minimal herbicide regime promote perennial broadleaf and grass weed species, while conventional tillage promotes certain annual grass and broadleaf weed species. However, the importance of seed destruction by arthropods and rodents in affecting these weed species compositional changes is unknown.

The present study had three objectives: 1) to quantify and compare arthropod weed seed destruction in low-input, conventional- and no-tillage systems (i.e., without insecticides and with minimal herbicide usage); 2) to elucidate selective feeding patterns shown by arthropods on specific weed seed species; and 3) to identify the major seed consumers in each system.

Materials and methods

Site description and experimental layout. Field experiments were conducted

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at the Central Crops Research Station, Clayton, North Carolina, USA, during October and November 1986, and involved 100 replicates in two 0.5-ha soybean fields planted in a wheat-soybean-corn rotation initiated in 1983. Tests were conducted at the beginning of October to coincide with peak natural weed seed release. Treatment plots were continuous no-tillage (NT) and chisel- and disk-plowed conventional-tillage (CT). No insecticides had been used in either of the treatments since 1983. Herbicide usage was kept to a minimum (1/2 to 1/4 of the rates recommended by North Carolina State University) (herbicides used since 1983 were: paraquat, glyphosate, alachlor, and linuron) and were applied early in the growing season 1-2 weeks before planting in order to reduce weed competition with the crops. A 5-m grassway separated the fields. Soil type was a Norfolk sandy-loam with < 1 percent organic matter and pH of 6.8. At the beginning of this study, the five most abundant weed species in these systems in descending order of abundance were: redroot pigweed (*Amaranthus retroflexus* L.), ragweed (*Ambrosia artemisiifolia* L.), common cocklebur (*Xanthium pensylvanicum* L.), lambsquarter (*Chenopodium album* L.), and jimsonweed (*Datura stramonium* L.). The few grasses present in these systems included *Panicum dichotomiflorum*, *Digitaria* spp., and *Setaria* spp.

After two years of minimal herbicide usage, 50 samples of a 24 cm^3 volume (6 cm by 2 cm by 2 cm) of soil contained a mean of 28.7 (range of 2-63) broadleaf weed seeds (pigweed, ragweed, lambsquarter, cocklebur, and jimsonweed) in no-tillage (NT), and a mean of 24.4 (range of 0-48) broadleaf weed seeds in conventional tillage (CT).

Since broadleaf weed species were the most abundant in these systems, seed consumption was examined for 3 of the 5 most common species of weed seeds: the broadleaf weed species used were: ragweed, redroot pigweed, and jimsonweed. Sicklepod (*Cassia obtusifolia* L.) was also used even though it was not found in our fields, because of its importance as a weed species in the southeastern United States. A grain crop species, wheat (*Triticum aestivum* L.) was also used. In North Carolina, wheat is often planted in the fall as a cover crop or a summer grain crop. In addition, a small amount of wheat seed falls to the soil surface during harvesting. Wheat seed densities (50 samples) in both CT and NT plots averaged 7.6 per 24 cm^3 with a range 5-21 in NT, and 3-20 in CT per 24 cm^3. For the seed species used in this study, any seeds with a weight of 8 mg or greater (sicklepod, jimsonweed and wheat) will be considered "large seed," while seeds with a weight of 2 mg or less (ragweed and pigweed) will be considered a "small seed" (Table 1).

Because of the wide range of weed and wheat seed density, two seed densities were used for each plant species: ragweed, 25 and 50 seeds/24 cm^2; pigweed, 25 and 50 seeds/24 cm^2; sicklepod, 10 and 25 seeds/24 cm^2; jimsonweed, 10 and 25 seeds/24 cm^2; and wheat, 10 and 25 seeds/24 cm^2. Seeds were held in place on 12.7- by 7.7-cm cardboard cards (seed cards) with two-sided tape covering an area of 24 cm^2. For comparative purposes, the 24 cm^2 area remained constant in this study; therefore, the larger-seeded species had lower seed densities per card than the smaller seed species. Seeds were held securely to cards, but seed feeders were still able to remove them (personal observation).

Seed-containing cards of each weed species were placed in each of five randomly selected 15-m sections of row located in both CT and NT treatments (5 seed species x 2 seed densities x 5 reps = 50 seed cards per treatment, 100 cards total). A minimum of 3 m between sections and 5 m from plot edges was maintained. Each card was placed ca. 3 to 5 mm below the soil surface, so that seeds were covered slightly with soil. In addition, the soil on the tape prevented the glue from entrapping or impeding soil organisms. In the NT system, crop residue was initially removed, then replaced over the seed cards.

Experiments began October 1, 1986, and terminated November 5, 1986. For the first 7 days, the cards were inspected every 24 hours. Thereafter, weekly checks were made. The effectiveness of the cards to retain seeds, in the absence of arthropods and rodents, was examined throughout the experiment by keeping control cards containing all seed species under 2 cm mesh wire cages in the fields, which prevented rodent feeding. They were also sprinkled with insecticide, diazinon, and a repellent, napthalene granules, to prevent arthropod seed feeding. The number of seeds remaining on all cards was counted weekly for 5 weeks. Seeds were counted directly in the field with a 10X hand lens. Twice per week, all cards were observed for seed feeding activity during the day (between 1200 h and 1700 h) and at night (ca. 1900-2300 h). Cards were cautiously approached from adjacent rows and any seed feeder actually observed feeding on seeds was recorded along with the species and density of weed seeds remaining on each card. At night, a flashlight was used to illuminate individual seed cards so that seed feeders could be recorded.

Table 1. Mean weight of 50 seeds of the seed species used in all experiments.

Seed species	Weight (mg)†
ragweed	10.31
pigweed	20.46
sicklepod	1,010.75
jimsonweed	410.30
wheat	1,880.19

† Fifty seeds were taken from a seed bag and weighed; the procedure was repeated four times.

Laboratory experiments. Since *Harpalus* spp. are considered predaceous on soil Lepidoptera (Brust et al., 1986), we wanted to discern whether two species, *Harpalus caliginosus* F. and *Harpalus pensylvanicus* DeGeer, the two most common carabids in our fields, would consume seeds in the presence of a nutritious meat resource. Therefore, in October and November an additional laboratory experiment was conducted which involved three field-collected ground beetle (Carabidae: Coleoptera) species: *H. caliginosus*, *H. pensylvanicus* and *Calosoma externum* Say. *C. externum*, an obligate predator, was included for comparison with the omnivorous *Harpalus* species. Each carabid was placed individually into a 35 x 22 x 10 cm box containing field soil and crop residue. The boxes (10 reps) were placed in rearing chambers at 20°C and 14:

(L:D) photoperiod. All three species of carabids were given free choice of five seed species: 20 g ragweed, 20 g pigweed, 20 g sicklepod, 20 g jimsonweed, and 20 g wheat, and, in addition, a protein ("meat") source: 20 g of moist high protein dog food. Previous experiments conducted in our laboratory found the moist dog food was as acceptable as lepidopteran larvae, pupae, or other insect prey to the carabids (Brust and House, unpublished data). The number of seeds consumed or damaged after a 24-h period was recorded for one week. The number of dog food pieces fed upon was also recorded at the same time seed damage was assessed.

Data were analyzed by analysis of variance and a Waller-Duncan separation procedure. Rates of seed loss are reported as the percentage of seeds removed/card/day to facilitate comparison of our results with other studies. In all calculations, where appropriate, number of seeds lost was corrected for by comparing to the controls, using the formula CV = (E - C/T) X 100, where CV = corrected percent value of seeds consumed, E = number of seeds missing on experimental cards, C = mean number of seeds missing on control cards, and T = total number of seeds on experimental cards at beginning of experiment.

Table 2. Mean percentage of total seeds removed by seed feeders over a five-week period (1 Oct.-7 Nov 1986) in no-tillage (NT) and conventional-tillage (CT) soybean systems.

Week	Tillage treatment	Mean percent consumed per week†	Mean percent consumed total†
1	no-tillage	7.96*	7.96*
	conventional-tillage	2.22	2.22
2	no-tillage	18.92**	26.88**
	conventional-tillage	6.72	8.94
3	no-tillage	14.33**	41.21**
	conventional-tillage	5.76	14.70
4	no-tillage	13.47*	54.68**
	conventional-tillage	6.55	21.25
5	no-tillage	13.85**	68.53**
	conventional-tillage	5.7	26.95

† Means are for total number of seeds consumed to that date, corrected for with the control and separated with Students *t* test.
* = $P < 0.01$; ** = $P < 0.001$.

Table 3. Mean percentage of five seed species removed from no-tillage soybean agroecosystems over a five-week period starting 1 Oct. 1986.

Seed species	Mean percentage consumed†				
	Week 1	Week 2	Week 3	Week 4	Week 5
Wheat	4.85 ab	24.96 a	38.23 a	49.30 a	61.67 a
Ragweed	6.91 a	16.76 c	32.20 b	41.83 b	50.53 b
Sicklepod	6.62 a	20.90 b	27.80 b	37.76 bc	46.73 bc
Pigweed	3.26 b	12.80 d	21.63 c	35.21 c	42.63 c
Jimsonweed	3.94 ab	14.07 cd	19.90 c	26.78 d	30.08 d

† Means are for the total number of seeds consumed to that date corrected for with the control, and are separated by a Waller-Duncan k ratio, t test. Means with different letters are significantly different at the $P \leq 0.05$ level.

Ragweed (*Ambrosia artemisiifolia* L.), sicklepod (*Cassia obtusifolia* L.), wheat (*Triticum aestivum* L.), jimsonweed (*Datura stramonium* L.), pigweed (*Amaranthus retroflexus* L.).

Results

Tillage effects. Throughout the 5-week period of the experiment, conventional tillage treatments had significantly less arthropod and rodent weed seed consumption than NT treatments ($P \leq 0.001$) (Table 2). Two to three times more seeds were consumed in no-tillage systems each week than in conventional-tillage systems.

Seed species effects. During the first week of this study, few seeds were consumed by predators, possibly because of the unusually hot, dry weather conditions present in the first week of October, and patterns of species preference were not established. However, by the second week wheat seeds were removed in greater numbers ($P < 0.05$) than other seed species, a general pattern that continued throughout the experiment. Second in preference were ragweed and sicklepod seeds (Table 3).

Seed density effects. Significant differences among seed density treatments ($P \leq 0.05$) occurred only in the first week. However, during weeks 2 through 5, there were no significant differences among seed densities ($P > 0.25$), indicating density independence for seed removal.

Interaction. The seed density X tillage and seed density X seed species interactions were not significant ($P = 0.21$) throughout the entire experiment; however, during the last four weeks of the experiment, there was a significant interaction between seed species and tillage ($P \leq 0.05$). Overall, the number of seeds of each species consumed was higher in NT than CT systems (Figure 1). There were ca. 152, 128, and 143 percent more ragweed, pigweed and sicklepod seeds consumed, respectively, in NT than in CT systems. Wheat was the most preferred seed species in both CT and NT, with only an 8 percent increase in consumption in NT as compared with CT systems. Consumption of sicklepod was 3.1 times greater in NT than CT.

Seed feeding organisms. Seed feeders were more abundant ($P \leq 0.05$) in NT than in CT systems (Table 4). Previous sampling in these agroecosystems over the last three years has shown similar results with significantly more carabids, crickets, and ants found in NT systems as compared with CT systems ($P \leq 0.01$) (House, unpublished data). Carabids had the greatest impact and importance in removing seed species in both agroecosystems, with *H. caliginosus* and *H. pensylvanicus* being the most abundant. *H. caliginosus*, a large carabid

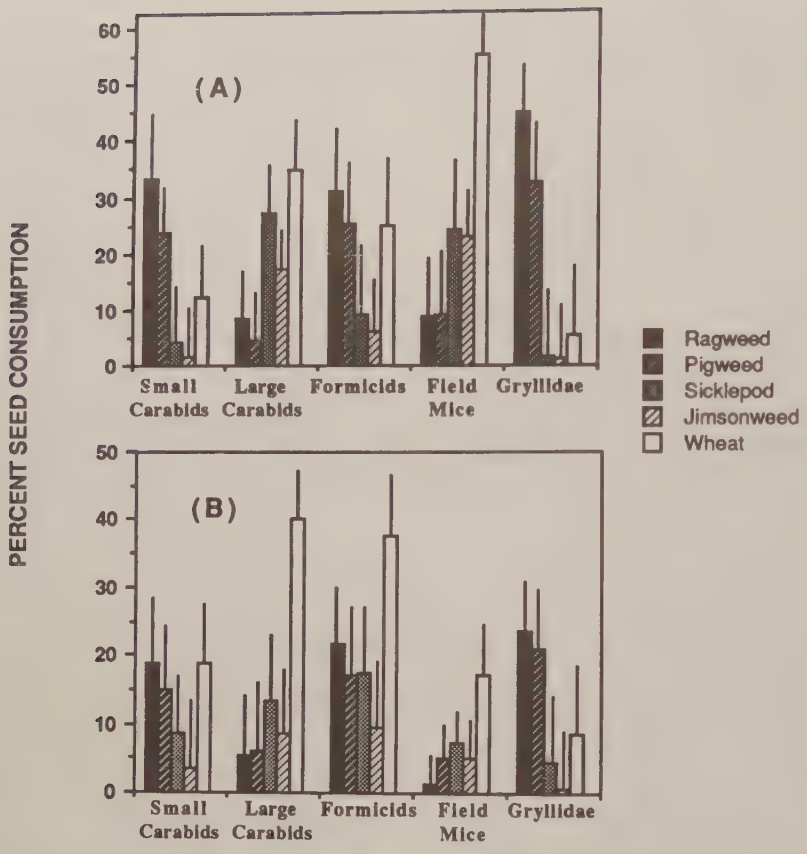

Figure 1. Relative percentage of each seed species consumed over the five-week period by seed feeders in (A) no-tillage soybeans following corn, and (B) conventional-tillage soybeans following corn. Small carabids: any species less than 15 mm in length; large carabids: any species greater than 15 mm in length. Bar on column represents 1 S.E.

species (ca. 26 mm long), was observed feeding on wheat and sicklepod seeds in great numbers in the second and subsequent weeks of the experiment. This carabid fed on jimsonweed, ragweed, and pigweed seeds less frequently. The smaller *H. pensylvanicus* species (approximately 14 mm in length) regularly consumed ragweed and pigweed seeds, showing a preference for ragweed (Figure 1).

During the first week of the experiment, *H. caliginosus* was unable to penetrate the pericarp of wheat or sicklepod seeds. After observing a carabid feed for about 3-4 min. on wheat, sicklepod, or jimsonweed seeds, the seeds were examined under a dissecting microscope in the laboratory. Numerous scratches and depressions were observed in the pericarp, but most seeds were still intact, hard, and presumably viable; only a few seeds had enough pericarp removed to enable the carabid to consume the endosperm. However, during the second week and subsequent weeks, observations of carabid (*H. caliginosus*) feeding showed that they could rapidly crush the seed (either wheat or sicklepod, but not jimsonweed) with their mandibles and consume the endosperm. *H. pensylvanicus* could also consume a wheat or sicklepod seed, but only after numerous attempts (i.e., *H. pensylvanicus* normally took 2-3 minutes to penetrate the pericarp).

A small carabid, *Selenophorus* sp., was the only other seed feeder to significantly remove seeds from the field (Table 4). Like other small carabids, *Selenophorus* preferentially removed the smaller seed species, such as ragweed and pigweed in the NT system, but removed relatively few seed species in the CT system (Figure 1).

Formicids (ants) were observed feeding on the smaller seed species in b tillage systems (Figure 1). However, the CT system ants also fed upon wh seeds to a greater extent than they in NT systems (Figure 1). Although a (*Pheidole* and *Lasius* spp.) were obser at seed cards both during the day a at night, they were generally the o seed feeders active during the day. the two small seed species, ants, as w as other seed feeders, showed a sli preference for ragweed seeds as co pared with pigweed seeds (Figure 1).

Crickets, *Gryllus* spp. (Gryllidae: thoptera), removed a substantial porti of the small weed seeds (Table 4), pecially ragweed, in the NT system, not as many in the CT system (Figu 1). Sixty-seven percent more crick were observed at seed cards in NT th CT systems.

Mice, mostly *Peromyscus manicula* (Wagner) with infrequent sighting *Mus* spp., were significant seed feed in the NT system, but not in the system (Table 4). In no-tillage fields, 1 percent more seed-consuming mice w observed feeding at seed cards caches compared with CT fields. In additi mice were the only seed consum which were consistently observed co suming the hard-shelled jimsonwe seeds (Figure 1).

Laboratory study. The two *Harpa* species primarily consumed seeds f lowed by the protein (meat) resou (Figure 2). In contrast, *C. externum* almost exclusively on the meat resour *H. pensylvanicus* consumed 60 perce of the ragweed seeds and less than percent of the wheat seeds. Sicklep and jimsonweed seeds were consum only in small amounts by *H. pensylv icus*. *H. caliginosus* preferred sicklep and wheat seeds as compared with ra weed and pigweed seeds, and also co sumed few jimsonweed seeds.

The two *Harpalus* species were for t most part unable to penetrate hard, d seeds such as wheat, sicklepod, and ji sonweed. These two carabids were a observed removing the larger seeds fr the source area and transporting th to covered areas (beneath straw, co stalks, etc.) within their laboratory co tainers to consume them.

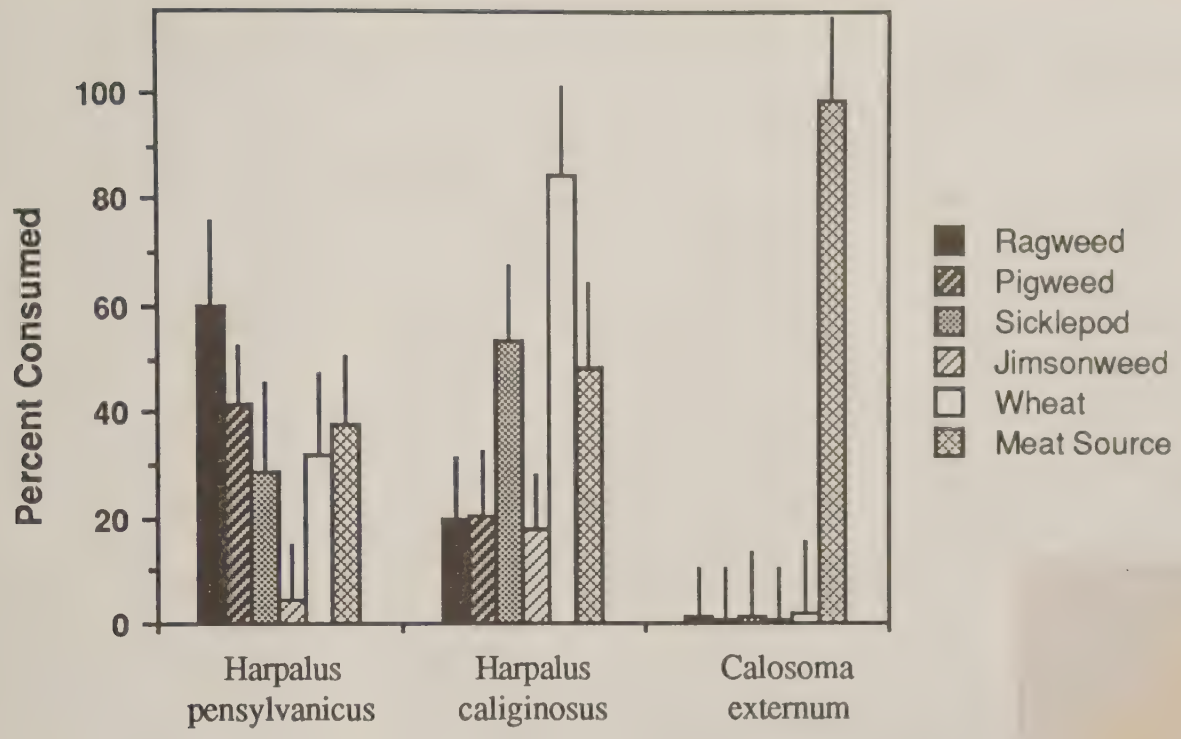

Figure 2. Laboratory studies of the mean percent of each type of seed species and protein resource consumed by three different carabid beetle species. Bar on column represents 1 S.E.

Conclusions

In the southeastern United States, CT systems (moldboard plow/disk) generally support fewer soil arthropods than NT systems (Blumburg and Crossley, 1983; House and All, 1981; House and Parmelee, 1985). Even soil disturbances in natural ecosystems can depress soil arthropod numbers, resulting in a concommitant reduction in seed feeding (Mittlebach and Gross, 1984).

In this study, weed-seed resource partitioning among soil arthropod groups and mice was evident. Large seeds such as wheat and sicklepod were preferred by large carabids and mice. Wheat seeds, especially, were consumed in large amounts in both experimental systems. Jimsonweed, the least preferred seed, was removed almost exclusively by mice, and only occasionally by the largest carabid species, *H. caliginosus* (Figure 1). Two smaller seed species, ragweed and pigweed, were removed by the smaller carabids, ants, and field crickets, although ragweed was preferred by most of these seed feeders. Wheat seeds have both a high protein content and high caloric content and thus provide mice and large carabids with a high energy return for their time spent in handling these seeds.

After seven days exposure in the field and probably as a result of moisture absorption and weathering, wheat seeds became soft enough for the larger carabids to easily penetrate their pericarps. Jimsonweed seeds did not soften significantly throughout the experiment and remained impenetrable to most arthropods. In addition to being easier to penetrate, wheat and sicklepod seeds are 4.6 and 2.5 times heavier, respectively, than jimsonweed seeds (Table 1), which probably provides a more favorable energy return/handling time ratio to both carabids and mice.

Small carabids, ants (in NT), and crickets were observed feeding at the seed cards on ragweed and pigweed seeds almost exclusively. Of these two smaller weed species, ragweed was slightly preferred over pigweed.

Individual mice were consistently observed (mice were identified by markings and physical differences, for example, bent or torn right ear, etc.), feeding in the same areas at specific times; however, individual carabids and other soil arthropods were not as recognizable at a similar level of resolution.

Although carabids and ants composed a greater proportion of the insects observed in CT systems (60 and 22 percent, respectively) than were observed in the NT systems (52 and 14 percent, respectively), the total number of seed feeders was consistently greater in NT than CT (Table 4). More total jimsonweed seeds were consumed in NT than in CT systems, apparently because populations of mice, the principal predator of jimsonweed seed, were reduced in CT systems. Even though the number of mice was low in CT, wheat seed consumption was similar in both systems, apparently because carabids and ants consumed more wheat seeds in CT as compared with NT (Figure 1).

Field observation of seed feeders at seed cards indicated that they remained for a longer period of time at seed cards in NT (an average of 3 to 4 minutes) than in CT systems (an average of 1.5 to 2 minutes) (Brust, unpublished data). The crop residue, lack of insecticide

Table 4. Arthropods and rodents observed feeding on seed cards in no-tillage (NT) and conventional-tillage (CT) agroecosystems and their significance as seed feeders.

Seed feeder	No. of times arthropods or rodents were observed at seed cards		Significance as a seed feeder	
	NT†	CT†	NT†	CT†
Carabidae (total)	380	167	0.38**	0.01
		Large Carabids (15–25 mm)		
Harpalus calignosus	128	63	0.62**	0.26**
Pterostichus spp.	21	9	0.16	0.01
Chlaenius spp.	12	3	0.12	0.02
		Small Carabids (< 15 mm)		
Harpalus pensylvanicus	101	41	0.25*	0.02
Agonum punctiform	10	2	0.04	0.03
Selenophorus spp.	25	8	0.38**	0.05
Anisodactylus spp.	18	3	0.12	0.03
Lebia spp.	10	10	0.03	0.05
Amara spp.	21	4	0.05	0.01
Bembidion spp.	27	22	0.04	0.09
Non-Carabids (total)	217	104	0.19*	0.05
Formicidae	70	55	0.50**	0.21*
Acari (Orbatids)	14	2	0.03	0.04
Field mice	67	25	0.31*	0.04
Gryllus spp.	36	11	0.28**	0.09
Lygaidae	7	4	0.02	0.01

† NT = field with no-tillage soybean following corn; CT = field with conventional-tillage soybean following corn.

Correlative value (Pearson's product moment r) of the relationship between the number of times a seed feeder was observed feeding at a seed card with the total number of seeds removed from that seed card in no-tillage and conventional-tillage agroecosystems.

* = $P < 0.05$; ** = $P \leq 0.01$; P values are of individual correlation coefficients for each system for each seed predator.

usage, reduced herbicide rate, and absence of soil and other disturbance in NT systems provided a more favorable microhabitat for seed feeders (i.e., increased moisture, refuge sites, etc.) (House and Parmelee, 1985). As observed in other studies (Barney et al., 1982; Brust et al., 1986), the exposed, dry microhabitats in CT were less conducive to extended periods of seed feeding.

In our alternative NT systems, mice were important seed feeders consuming mainly wheat and sicklepod seeds. Rodents have been shown to be important seed consumers in other studies (Brown et al., 1975; Janzen, 1971; Mittlebach and Gross, 1984). However, in our CT system, as in other disturbed systems (Holbrook, 1975; Kaufman and Fleharty, 1974; Price and Waser, 1984), mice had little importance as seed consumers (Table 4).

Although ants were important seed feeders in CT systems, their total number was higher in our NT than in CT systems; ant activity was also reduced in disturbed systems in other studies (Mittlebach and Gross, 1984).

In this study, the number of seeds consumed per day per unit area was low in comparison with the number observed in other studies. Seed removal rates of 5-60 percent per day (Platt, 1976) and 10-70 percent per day (Reichman, 1979) have been reported for ants and rodents under natural conditions (i.e., non-agricultural systems). Mittlebach and Gross (1984) reported that old-field biennial seed species losses were 10-20 percent per day. In the present study, the maximum rate of seed removal was 4.2-4.8 percent per day in the NT system (Table 5). Although NT agroecosystems mimic 'natural' systems more closely than CT systems (House et al., 1984), they remain agricultural systems subjected to various inputs and disturbances. Soil arthropods are oft
omnivorous and opportunistic, consu
ing seeds in addition to other fo
sources. Seed feeders, therefore, may
fluence weed species composition in r
tillage systems through feeding pref
ences as well as by total amount of we
seed removed. Furthermore, we appli
only a single low rate preemergence h
bicide at planting, so that our expe
mental low-input, no-tillage fi
probably supported higher mature we
populations than the average no-tilla
field. However, grain yields from c
low-input systems were not significan
different from those in our conventio
tillage system.

In conclusion, our research indica
that soil arthropods, especially carab
beetles, were important consumers
weed and wheat seeds in our expe
mental low-input, NT systems. Only
small percentage (ca. 5-10 percent)
weed seeds in the soil-seed bank res
voir germinate each year (Kropac, 19
Wilson et al., 1985). However, in r
tillage systems most of the seeds th
germinate in a single season are on
within the surface 2 cm of soil, exposi
them to seed consumption. In low-inp
no-tillage systems, ground-dwelling a
thropods and mice may destroy enou
weed seeds of a certain weedy species
influence the composition of the su

Table 5. Mean number of seeds consumed pe
day per unit area† in no-tillage (NT) and
conventional-tillage (CT) agroecosystems.

Seed species	Mean number of see consumed per day p 24 cm²	
	NT*	C
wheat	4.78 a	2.24
ragweed	4.21 a	1.85
sicklepod	4.00 a	1.88
pigweed	2.64 b	1.53
jimsonweed	2.16 b	0.82

† Calculated as $P = 100\ (1 - r^{1/t})$; P = m
percentage of seeds consumed/day/24 cm² a
r = mean proportion of seeds remaining at
of experiment; t = duration of experiment in da

All mean comparisons between NT and CT
significantly different at the 0.01 level, Studen
test.

* Means followed by the same letter for a till
system are not significantly different ($P \geq 0$
level) Waller-Duncan K-ratio t test.

ceeding season's weed community. Finally, we are inclined to think that regular pesticide usage in high-input systems may severely limit seed feeding activity through continuous destruction of arthropod and weed populations.

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RESOURCES

The Invisible Diet, a report from the California Assembly Office of Research, analyzes that state's program to protect consumers from pesticide residues in food. Two-thirds of pesticides now in use are not picked up with normal testing, and California should put a stronger protection program in place, the report says. Specifically, it recommends identification of pesticides which pose a health risk, a stronger monitoring program, and a tax to fund the effort. Copies are $7.50 from the Joint Publications Office, State Capitol, Box 942849, Sacramento, CA 94249.

A National Directory of Non-Point Source Contacts, from the Conservation Technology Information Center, lists the chief contacts for state-level departments, the Soil Conservation Service, and the Environmental Protection Agency. Contact the CTIC, 1220 Potter Drive, Room 170, Purdue Research Park, West Lafayette, IN 47906.

Switching to a Sustainable System, by Frederick Kirschenmann, is a practical guide for farmers interested in moving to low-input systems. Copies are $3 from Northern Plains Sustainable Agriculture Society, RR 1, Box 73, Windsor, ND 58424.

Alternative Agriculture, the report of a Purdue University Task Force, points to shortage of funds and lack of talented individuals for adaptive research as chief obstacles in the path of alternative farm research at that university. It recommends the appointment of a Coordinator for Low Input/Alternative Agriculture, funding for a program, and designation of research sites. The report is from the Purdue Agricultural Experiment Station, West Lafayette, IN 47907.

Conservation Easements: Prospects for Sustainable Agriculture, by Justin Ward of the Natural Resources Defense Council (NRDC), argues that such easements could help build new soundness in farms and rural communities. Ward cites the use of easements to retire severely eroding farmland from crop production or to protect ground water. If the property owner could retain the right to graze livestock, have a tree farm, or provide hunting rights on such lands, both individual farm income and the rural economy might benefit, he says. The report is available from the NRDC, 1350 New York Avenue, NW, Suite 300, Washington, DC 20005.

Factors influencing the economic potential for alternative farming systems: Case analyses in South Dakota

Thomas L. Dobbs, Mark G. Leddy, and James D. Smolik

Abstract. *Results of calculations on the economic potential for alternative (low input, sustainable) farming systems in a small grain-row crop region of the Northern Plains are reported. Two sets of alternative farming systems, in which no chemical fertilizers or herbicides are used, are compared with various conventional and reduced till systems. In Farming Systems Study I (FSS1), an alternative rotation consisting of oats, alfalfa, soybeans, and corn is compared with conventional and ridge till rotation systems composed of corn, soybeans, and spring wheat. In Farming Systems Study II (FSS2), three systems with an emphasis on small grains are compared. An alternative system rotation consisting of oats, sweet clover, soybeans, and spring wheat is compared with conventional and minimum till rotation systems comprised of soybeans, spring wheat, and barley. Results of baseline economic analyses show that alternative farming systems can be competitive with more conventional systems in at least some situations. The alternative systems entail markedly lower direct costs, and the alternative system in FSS2 has approximately the same net returns as the comparable conventional and minimum till systems. The FSS1 alternative system has positive but somewhat lower net returns than the comparable conventional and ridge till systems. Sensitivity analyses were conducted with alternative system crop yields, chemical fertilizer and herbicide prices, and varying assumptions about future Federal farm program support levels and acreage set aside requirements. The yield sensitivity analyses show that one alternative farming system requires yields about 5-10 percent above those of the comparable conventional system to produce the same net returns. However, the other alternative system is competitive with a conventional system even with yields 5 percent lower. Analyses varying chemical fertilizer and herbicide prices reveal that the alternative farming system in FSS1 becomes competitive with more conventional systems when fertilizer and herbicide prices rise by 50 percent. The alternative farming system in FSS2 is already competitive at current fertilizer and herbicide prices. In some cases, sensitivity analyses with Federal farm program provisions indicate that reductions in farm program benefits increase the economic competitiveness of alternative farming systems. However, important exceptions occur. Results indicate that not only the level of future farm program benefits, but also the form of program provisions and compliance requirements, will affect the relative competitiveness of alternative farming systems.*

Key words: alternative farming system, conventional till, reduced till, oats, barley, alfalfa, sweet corn, soybeans, spring wheat

Introduction

Environmental and economic pressures have stimulated increased interest in alternative farming systems in the Northern Plains. Alternative farming systems labeled by such terms as "organic," "low input," "reduced input," "sustainable," and "regenerative" are currently an object of attention for a small but rapidly growing number of agronomists, agricultural economists and policy makers. More significantly, farmers are now asking "What are the costs and returns of alternative farming systems, relative to more conventional systems?"

Relatively few studies have systematically documented the costs and returns of alternative farming systems. However, a few such studies have been reported in this journal (e.g., Helmers et al., 1986; Domanico et al., 1986; Dabbert and Madden, 1986; and Goldstein and Young, 1987) and elsewhere (e.g., Shearer et al., 1981; Duffy, 1987; and Lockeretz et al., 1981). These reflect an important initial effort to build an information base on the economics of alternative farming systems.

Cacek and Langner (1986) also provide an excellent review of several economic studies of organic farming. Before widespread extension efforts can be undertaken to recommend particular alternative systems, however, more research in different agroclimatic regions of the U.S. is needed. In addition, more in-depth analysis of the multiple factors determining the on-farm economics of alternative farming systems is essential.

With these informational needs in mind, faculty of the Agricultural Experiment Station at South Dakota State University began research on alternative farming systems with a group of farmers in east-central South Dakota in 1984. Building in part on experience gained

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with these farmers, they initiated a long-term set of agronomic trials to test alternative systems in 1985 at the Northeast Research Station, near Watertown in east-central South Dakota. Two sets of alternative farming systems are being compared with various conventional and reduced till systems. Scientists from a variety of plant science disciplines, together with agricultural economists, are engaged in this project. Involvement of economists early in the project facilitates isolation of certain key parameters likely to affect ultimate farmer acceptance of alternative farming systems. Preliminary economic findings contribute to the multidiscipline research teams' decisions about factors to explore in greater depth.

A major objective of this research relates to determination of factors that influence the economic potential for alternative farming systems. This will be accomplished in three phases: (1) analyses based upon "normalized" crop enterprise budgets and whole farm analyses, early in the project; (2) surveys of farmers who are trying alternative farming systems; and (3) on-going enterprise budget and whole farm analyses, as more definitive production function data are generated over the life of the project. In the present article, we report results of analyses conducted in the first phase.

Data and methods are explained in the following section. Systems examined are described, and the bases for establishing key agronomic and economic assumptions are explained. In the next section, results of baseline analyses and a summary of extensive sensitivity analyses are presented. "Normalized" budgets and 1987 Federal farm program provisions were used for the baseline analyses. Results are then tested for sensitivity to changes in assumptions about relative crop yields, fertilizer and herbicide prices, and Federal farm program provisions and product prices. Implications of these findings regarding the economic prospects for alternative farming systems are presented in the concluding section.

Methods

Studies of farming systems at South Dakota's Northeast Station are grouped into two sets of comparisons. In Farming Systems Study I (FSS1), row crops are emphasized, and the *alternative* rotation, which involves no chemical fertilizers or herbicides, is compared with *conventional* and *ridge till* rotations. Oats (which are harvested and also serve as a nurse crop for alfalfa), alfalfa harvested as hay, soybeans, and corn (in that order) are included in the 4-year alternative rotation. Corn, soybeans, and spring wheat (in that order) are included in both the conventional and the ridge till 3-year rotations. Fertilizer and herbicides are applied at recommended rates in the latter two rotations.

The ridge till and conventional systems differ in tillage operations and herbicide use. A moldboard plow is used following spring wheat in the conventional rotation, whereas a chisel plow is used after spring wheat harvest in the ridge till system. Also, there are no spring preplant tillage operations in the ridge till system. The ridge till system entails somewhat greater use of herbicides. Details of tillage practices, chemical fertilizer and herbicide use, labor requirements, etc., for each system are contained in Dobbs et al. (1987).

In Farming Systems Study II (FSS2), three systems with an emphasis on small grains are compared. The *alternative* rotation consists of oats (harvested and a nurse crop for sweet clover), sweet clover, soybeans, and spring wheat. Sweet clover is included as a green manure crop; it is mowed prior to seed set, but not harvested. As in Study I, no chemical fertilizers or herbicides are used in the alternative rotation. *Conventional* and *minimum till* rotations in FSS2, in which fertilizers and herbicides are used, include soybeans, spring wheat, and barley. In the minimum till system, a chisel plow is used after small grain harvest, whereas a moldboard plow is used in the conventional system. Details of the cultural practices for each system in Study II are listed in Dobbs et al. (1987).

The alternative system in FSS1 is patterned after a system used by some farmers in east-central South Dakota with whom SDSU researchers have collaborated. Both corn and soybeans are grown

Table 1. Output Price Assumptions.

	Crop					
	Corn	Soybeans	Oats	Alfalfa	Barley	S. Wheat
Units	bu	bu	bu	ton	bu	bu
Selling price ($/unit)	$1.66[1]	$5.00	$.88[1]	$30.00	$1.40[1]	$2.37[1]
Deficiency Payment ($/bu)	$1.21	n.a.	$.66	n.a.	$1.11	$2.10
Base Yield (bu/acre)	63	n.a.	53	n.a.	41	27

[1] Loan rate
n.a. = Not applicable.

Table 2. FSS1 and FSS2 Set Aside Requirements and Rotation Distributions.

	Crop							
	Corn	Soybeans	Oats	Alfalfa	Barley	S. Wheat	S. Clover	Set Aside
Set Aside Requirement (%)	20	0	20	0	20	27.5	0	n.a.
Crop Distribution (Acres)								
FSS1								
Alternative	120	120	120	120				60
Conventional	149	149				149		93
Ridge Till	149	149				149		93
FSS2								
Alternative		135	135			135	135	0
Conventional		149			149	149		93
Minimum Till		149			149	149		93

n.a. = not applicable.

extensively in this area. Of particular interest in FSS1's alternative system is the economic viability of a rotation in which the forage legume is harvested in only 1 year, rather than in the more traditional 3 or 4 years per stand.

FSS2 contains systems which are representative of, or potentially more suitable for, areas slightly farther north in eastern South Dakota. As one moves north in eastern South Dakota, average rainfall tends to decline and the frost-free growing season shortens. Small grains take on increasing importance relative to row crops.

Rather than to use directly only the first 2 years (1985 and 1986) of production practice and yield data, which were available when the crop enterprise budgets were constructed during 1987, we drew on a variety of sources to estimate the "normalized" budgets reported in this article. These budgets are based on a combination of field trial experience to date, reviews of literature and historical data, and scientific judgment concerning expected long-term practices and yields for these systems. In making yield estimates, attempts were made to account for yield interactions caused by rotations. Detailed budgets, sources of information, and documentation of assumptions are found in Dobbs et al. (1987).

Table 3. "Normalized" Yield Summary.

Farming Systems Study I

	Yield (bu. or ton)/Acre				
	Corn	Soybeans	S. Wheat	Oats	Alfalfa
Alternative	75	28		70	3.6
Conventional	82	30	42		
Ridge Till	84	31	42		

Farming systems Study II

	Yield (bu.)/Acre				
	Barley	Soybeans	S. Wheat	Oats	S. Clover
Alternative		27.5	40	70	Not harvested
Conventional	70	30	42		
Minimum Till	65	30	42		

Input and output prices for the enterprise budgets were based on 1987 conditions. The relationships in recent years between open market prices and prices received through participation in the Federal farm program have been such that the vast majority of South Dakota and other Northern Plains farmers have participated in the program. Thus, for spring wheat, corn, oats, and barley, we assumed 1987 farm program provisions and farmer participation. No acreage set aside has been required for farmers to avail themselves of farm program loans on soybeans. However, unlike the situation with the food and feed grains, soybean market prices were generally above the loan price for eastern South Dakota during 1987. Therefore, we assumed a market price return for soybeans. (Some storage cost was assumed, so that soybeans would not have to be immediately marketed at harvest time.) Alfalfa could be either fed or sold; it was valued at a conservatively estimated local market price. Prices and farm program payments used in the analysis, along with local farm program base yields used in calculating deficiency payments, are shown in Table 1.

Enterprise budget data were then incorporated into whole-farm analyses for a medium size family farm having an assumed 540 acres of crop land. Farm size and growing conditions were representative of the area near the Northeast Station.

Allocation of acreage to each crop on

Table 4. Results of Farming Systems Analyses Based upon "Normalized" Budgets.

	Dollars/Acre					
			Net Income Over			
System[1]	Direct Costs Other Than Labor	Gross Income	All Costs Except Land, Labor, and Management	All Costs Except Land and Management	All Costs Except Management	Whole Farm, Net Income Over All Costs Except Management[2]($)
Farming Systems Study I						
1. Alternative (soybeans-corn-oats-alfalfa)	42	121	49	36	10	5,385
2. Conventional (corn-soybeans-s. wheat)	63	143	54	45	19	10,372
3. Ridge Till (corn-soybeans-s. wheat)	65	145	58	51	25	13,273
Farming Systems Study II						
1. Alternative (soybeans-s. wheat-oats-s. clover)	30	96	41	31	5	2,767
2. Conventional (soybeans-s. wheat-barley)	57	124	40	30	4	2,126
3. Minimum Till (soybeans-s. wheat-barley)	61	122	38	30	4	2,234

[1] Crops are shown in the order in which they occur in each rotation.
[2] For farm with 540 tillable acres. Figures in this column are equivalent to 540 multiplied by "prerounded" figures in the "all costs except management" column.

the 540-acre farm was made in such a fashion that (a) the farm was in compliance with 1987 farm program minimum set aside requirements *and* (b) equal acreage was devoted to each crop in the rotation. The method for calculating the acreage allocations is described and demonstrated in Dobbs et al. (1987). Set aside requirements and resulting acreage distributions for each crop in FSS1 and FSS2 are shown in Table 2.

With acreage distributions specified, it was then possible to determine the net returns in each system. Livestock enterprises are not included in the whole farm results reported here, though we have incorporated such enterprises in analyses elsewhere (Leddy, 1987).

Baseline analyses for the 540-acre farm were conducted with the use of the normalized budget and farm program assumptions specified above. Yields used in these analyses are shown in Table 3. Alternative system yields were set 5 to 9 percent below conventional system yields for the various crops. Since our budgets were based on assumed conditions after the yield transition stage has passed, the estimates of alternative system yields may be conservative. However, our assumed differences between alternative and conventional system yields are generally consistent with reports by such authors as Helmers et al. (1986) and Lockeretz et al. (1981). Some other reports indicate that alternative system yields eventually equal conventional system yields, after the transition phase has passed (e.g., U.S. Department of Agriculture, 1980).

Results and discussion

Baseline analyses

Results of the baseline analyses are summarized in Table 4. The per acre figures are composites of all crops and set aside in each system. "Direct costs other than labor" provide an indication of the required direct cash outlay for each of the systems. "Gross income" is derived from yield data in combination with farm program and market price (for soybeans and alfalfa) information described earlier.

The next three measures in Table 4 indicate per acre returns over costs. The first measure, "income over all costs except land, labor, and management", views land, labor, and management as fixed--thereby having no opportunity cost. "Income over all costs except land and management" is the same as the previous measure, except that a charge for labor has now been included. Inclusion of a labor charge affects some systems more than others because of differences in labor requirements across systems. If one ignores management as a separate factor of production, this measure can also be viewed as the amount of money available to cover either the annual rental charge or the annual ownership costs associated with land. The final measure in this group of three, "income over all costs except management", indicates the profitability of each system when all costs are accounted for except a charge for the producer's management. Inclusion of the land charge affects all systems by the same dollar amount, since land of equal quality in the same geographic region is used for each system.

The final measure shown in Table 4 is "whole farm net income over all costs except management". This has the same meaning as the immediately preceding column. However, here the net income is presented as an aggregate value for the total tillable acres.

Results in Table 4 show that the alternative systems have significantly lower direct costs (other than labor) than the other systems. All systems cover full costs (including land) when 1987 farm program provisions are in effect. The various net income figures for the alternative system are \$5 to \$15/acre lower than those for the other systems in FSS1 and are nearly the same as those for the other systems in FSS2. The baseline results demonstrate that alternative systems offer opportunities to substantially reduce cash operating costs. Moreover, with at least some alternative systems, there may be little or no sacrifice of net income.

Since a conservatively estimated alfalfa hay price of \$30/ton was used in baseline analyses for the alternative system in Study I, other prices were also used to observe the effects on competitiveness of this system. However, sub-

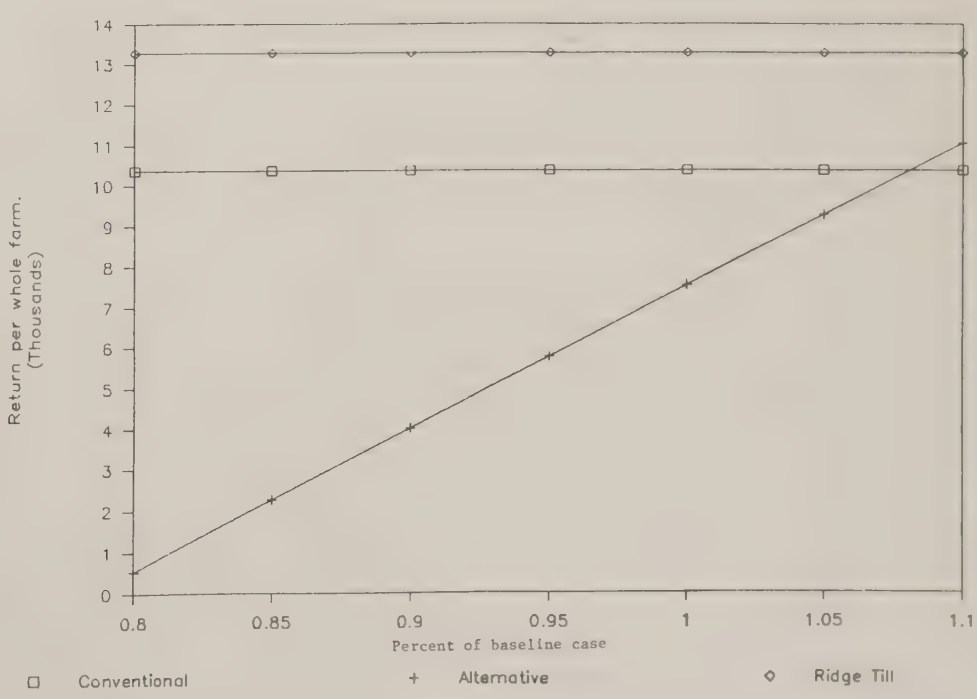

Figure 1. Effects on farm net returns of varying yields of the alternative system crops in Farming Systems Study I. Conventional and ridge till system crop yields are left at baseline levels.

stantial increases (going up in $5/ton increments) were required to make the alternative system as profitable as the other two systems in Study I. When alfalfa hay was valued at $45/ton, the alternative system became more profitable than the conventional system. Increasing the price further to $50/ton caused the alternative system to outperform both the conventional and the ridge till systems in Study I. Hay prices can be very volatile from year to year. Thus, rather than risk overvaluing alfalfa hay, we continued to use $30/ton as the baseline price.

Yield sensitivity analyses

We mentioned earlier in this article that evidence in the literature differs on the relationship between yields in alternative and conventional systems. Our own research at SDSU in examining this relationship needs to be continued for several years. Therefore, we examined the effects of a range of relationships on the economic competitiveness of alternative farming systems. Results of the principal analyses are summarized in Figures 1 and 2.

The sensitivity analyses with yields were conducted by setting the alternative system yields at particular levels in relationship to conventional baseline yields. Thus, a 10 percent lower yield for a particular crop indicates that the specified alternative system yield was assumed to be 10 percent lower than the conventional system yield. Oats and alfalfa were treated somewhat differently, because there were no counterparts in the conventional systems. When the yields of those two crops were altered, they were altered from the baseline alternative system yields.

Results of sensitivity analyses with FSS1, in which alternative yields of oats, corn, and soybeans (but not alfalfa) were varied, are shown in Figure 1. Effects on whole farm returns, represented by income over all costs except management, are shown. The range of alternative system yields examined was from 20 percent below conventional system yields to 10 percent above. Results indicate that the alternative system maintains a slightly positive net return even when yields are 20 percent *lower* than conventional system yields (Figure 1). At some point between 5 and 10 percent *above* conventional system yields, the alternative system becomes as profitable as the conventional system, although it still is not as profitable as the ridge till system in FSS1.

In the FSS2 analysis, the alternative system yields of oats, soybeans, and spring wheat were varied. Sweet clover was unaffected, because it is not harvested. Results shown in Figure 2 indicate that the alternative system provides more than twice the net return of either the conventional or the minimum till system when it has the same yield levels as the conventional system. The alternative system is just *as* profitable as the other two systems even with yields 5 percent lower than conventional system yields, but it becomes less profitable when yields approach 10 percent lower. Yields 15 percent lower than conventional system yields cause net returns for the alternative system to become negative; i.e., all costs other than management are *not* covered.

The yield sensitivity analyses in Figures 1 and 2 could be viewed as transition phases. Following Dabbert and Madden's (1986) linear recovery approach, we could assume alternative system yields start out lower than conventional system yields, but steadily recover. Different whole farm net returns result, depending on the assumed initial yield penalty, the time span for yield recovery, and the extent of recovery. For example, in FSS1, even if alternative system yields were to eventually reach or exceed those of the conventional system, several years in which alternative system yields were 5 10 percent lower could cause severe cash flow problems for the farm.

Sensitivity analyses (not shown on the figures) also demonstrated the critical role of alfalfa yields. For example, a 1 percent increase in alfalfa yields caused the alternative system net returns to increase by 36 percent; net returns for the alternative system at that alfalfa yield level (4.14 tons/acre) still do not equal those of the conventional and ridge till systems in Study I, however. In the last 2 years (1986 and 1987) of completed trials at SDSU's Northeast Station, alternative system alfalfa yields have been 6.14 and 4.43 tons/acre. Several more years of data are needed, however, to have confidence in what yields to expect on average.

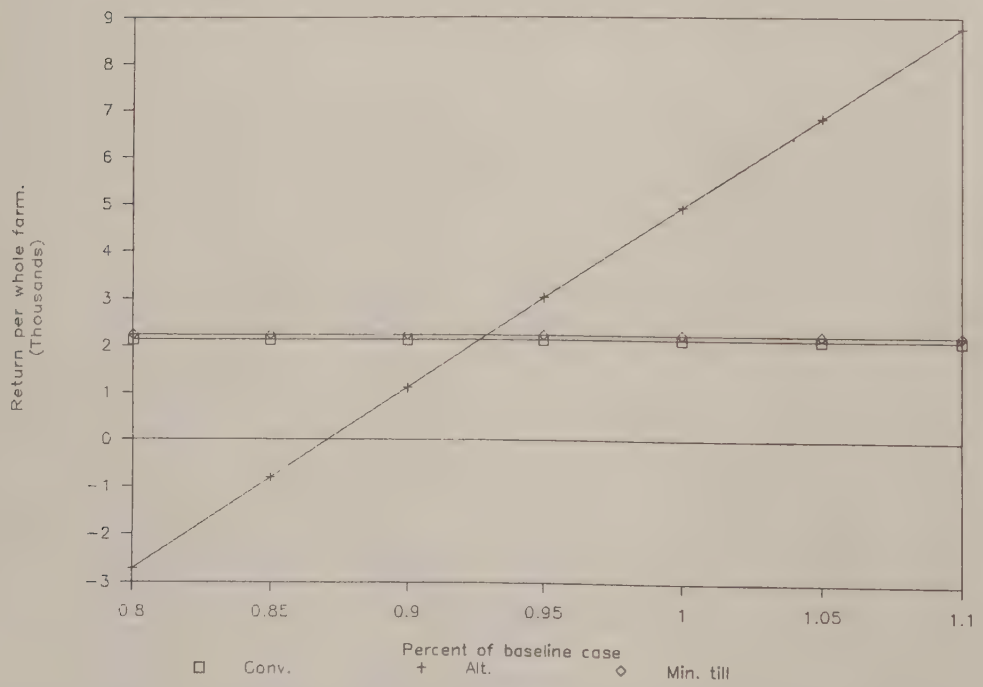

Figure 2. Effects on farm net returns of varying yields of the alternative system crops in Farming Systems Study II. Conventional and minimum till crop system yields are left unchanged.

Chemical input price sensitivity analyses

Future increases in petroleum prices would be expected to increase the relative economic attractiveness of alternative farming systems, due to the associated effects on costs of petroleum based chemical inputs used in more conventional systems. The effects of separate changes in the prices of fertilizers and herbicides and of a simultaneous change in the prices of both were analyzed. Over the long term, one would expect the prices of nitrogen fertilizers and petroleum based herbicides to move together. Thus, only the combined changes are discussed here.

Results of these sensitivity analyses are shown in Figures 3 and 4. Return per whole farm in these two figures has the same meaning as described previously for Figures 1 and 2. The baseline fertilizer situation represents $0.18 per pound for both nitrogen and phosphorus fertilizer.

A 50 percent increase in both fertilizer and herbicide prices causes conventional system net returns to fall below those of the alternative system in FSS1 (Figure 3) and ridge till system net returns to fall almost to the level of those for the conventional system. In FSS2, a 25 percent increase in fertilizer and herbicide prices causes both conventional and minimum till system net returns to fall to negative levels (Figure 4). The impact on the minimum till system was greatest, because of its greater reliance on herbicides for weed control. Decreases in fertilizer and herbicide prices, of course, decrease the relative economic attractiveness of the alternative system.

Increases in relative prices of petroleum based fertilizer and herbicide inputs seem far more likely over the long term than do decreases. Though experiences of the last 15 years lead one to expect continued volatility in petroleum and petroleum product prices, it appears reasonable to expect an upward price trend. Limited known world oil reserves, long-term world economic growth, and political instability in the Middle East all contribute to this expectation. Such a trend would enhance the economic attractiveness of alternative farming systems.

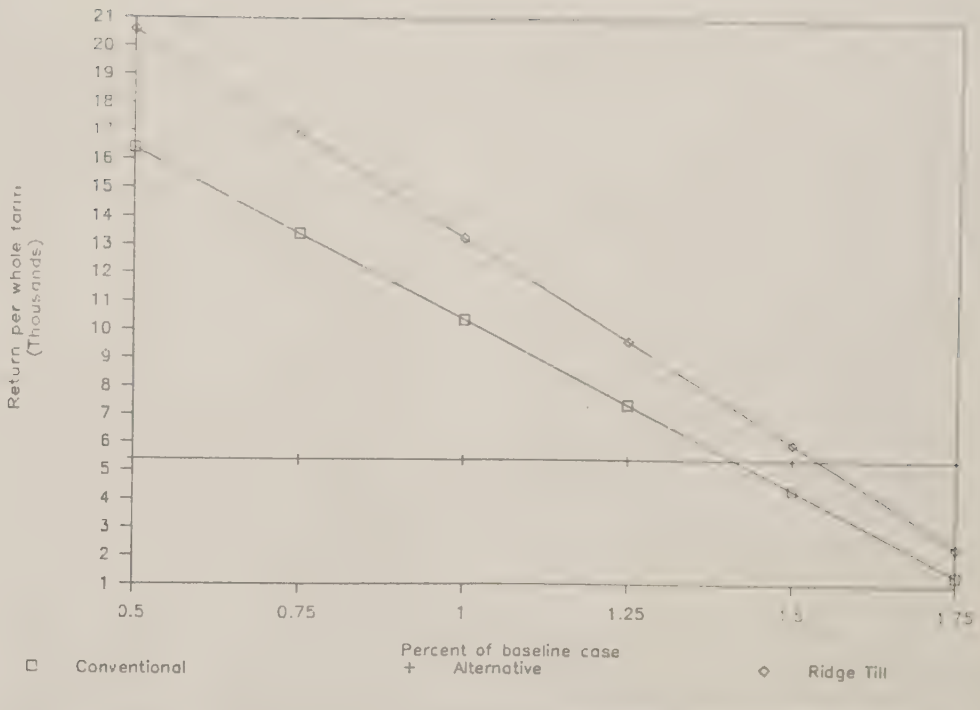

Figure 3. Effects on farm net returns of varying prices of fertilizers and herbicides used in the conventional and ridge till systems of Farming Systems Study I.

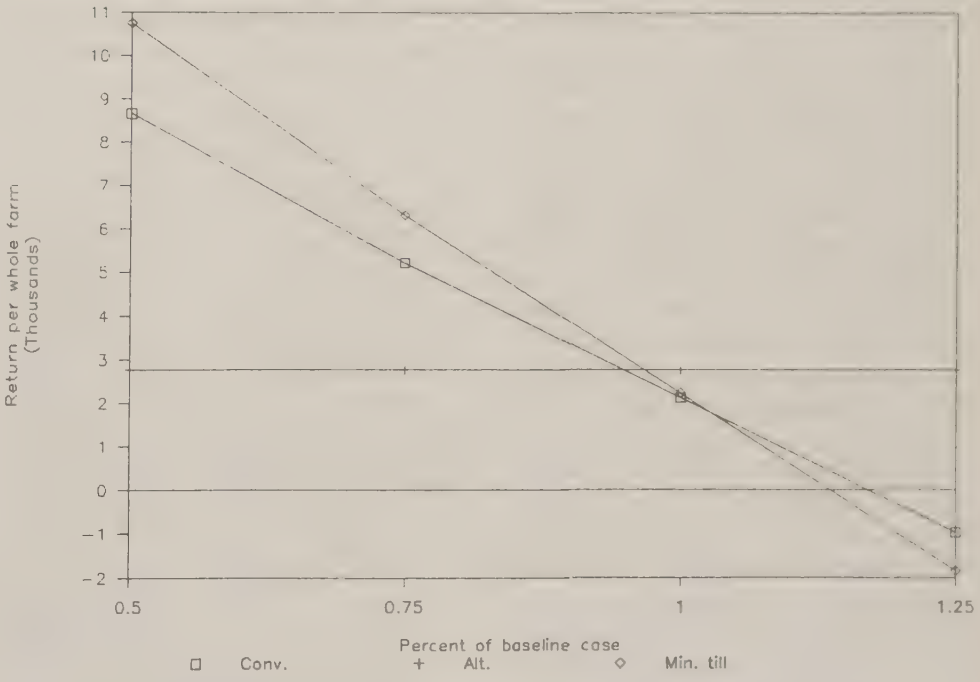

Figure 4. Effects on farm net returns of varying prices of fertilizers and herbicides used in the conventional and minimum till systems of Farming Systems Study II.

Farm program sensitivity analyses

Many people feel that the high market prices experienced for a time in the 1970s, followed by relatively high government farm program support levels in the 1980s, have tended to encourage high yield-high cost farming systems. If

correct, it seems reasonable to hypothesize a reverse effect--that lower farm commodity prices and reduced Federal farm program support levels tend to increase the economic attractiveness of alternative farming systems, relative to more conventional systems. Findings of Goldstein and Young (1987) support that hypothesis.

We have made comparisons somewhat similar to Goldstein and Young's in our sensitivity analyses, though with more detailed farm program assumptions. We explicitly accounted for farm program set aside requirements, as described earlier in this article. This turned out to be an important consideration as changes were made in the farm program assumptions.

Numerous agricultural policy alternatives have been proposed, leading up to and following passage of the Food Security Act of 1985 (e.g., see Knutson et al., 1987). Drawing key elements from some of the proposed alternatives, several scenarios were defined to include in our farm program sensitivity analyses. Included, one at a time, were (a) reduced target prices, (b) increased set aside requirements, and (c) complete elimination of the Federal farm program. In these analyses, changes in "income over all costs except land and management" for each system were measured. This income measure was used to observe what would be available from each system to cover both land and management when farm program benefits are reduced.

As expected, *reductions in target prices* impacted the conventional, ridge till, and minimum till systems more than the alternative systems. All systems showed substantial declines in net returns when target prices were reduced by 15 percent (Leddy, 1987). However, the absolute declines were somewhat less for the alternative systems in both FSS1 and FSS2 than for the other systems to which they were compared.

Similarly, the alternative systems experienced the smallest absolute declines in net returns in both FSS1 and FSS2 when *set aside requirements were increased* (starting from the levels specified in Table 2), in steps, up to 35 percent of base acreages. Since unharvested sweet clover qualifies as set aside, net returns for the alternative system in FSS2 did not decline at all until the last increment--moving from 32.5 to 35 percent--was tested (Leddy, 1987). Before reaching that point, sweet clover acres in the rotation were sufficient to meet the set aside requirements.

Results were mixed, however, when some *"no farm program" scenarios* were examined. In one scenario, set aside requirements were eliminated and prices of corn, oats, barley, and spring wheat were reduced to market prices equivalent to the 1987 eastern South Dakota loan levels shown in Table 1. Soybeans and alfalfa were left at the 1987 market levels specified in Table 1. This scenario, with very low market prices, is similar to that analyzed by Goldstein and Young (1987). As in our other sensitivity analyses, the alternative systems experienced less decline in net returns than did the comparison systems in both FSS1 and FSS2, and the alternative system in FSS1 became more profitable than the conventional system (Leddy, 1987).

Results of a probably-more-realistic "no farm program" scenario are shown in Figures 5 and 6. Here, it is assume that a period of supply and demand ad justment would result in "real" (infla tion adjusted) market prices for all crop in the system (except alfalfa) which ar lower than the 1987 target and marke prices implied in Table 1 but higher tha the 1987 loan rates shown. A comple set of interrelated adjustments would b involved in reaching a new set of equi librium prices. Formal analysis of such an equilibrium was beyond the scope o our study. Instead, we assumed prices at 70 percent of 1987 target or market levels. Therefore, the per bushel prices assumed for each crop were: corn ($2.01), soybeans ($3.50), oats ($1.08), barley ($1.76), and spring wheat ($3.13). Since (as noted earlier in this article) th baseline alfalfa price was a somewha conservative $30/ton, we initially lef that price unchanged.

Net returns for all systems declined of course, when these price assumption were substituted for the baseline farm program price assumptions. Although net returns declined less (in absolute terms) for the alternative system than for the other systems in FSS1, the rank

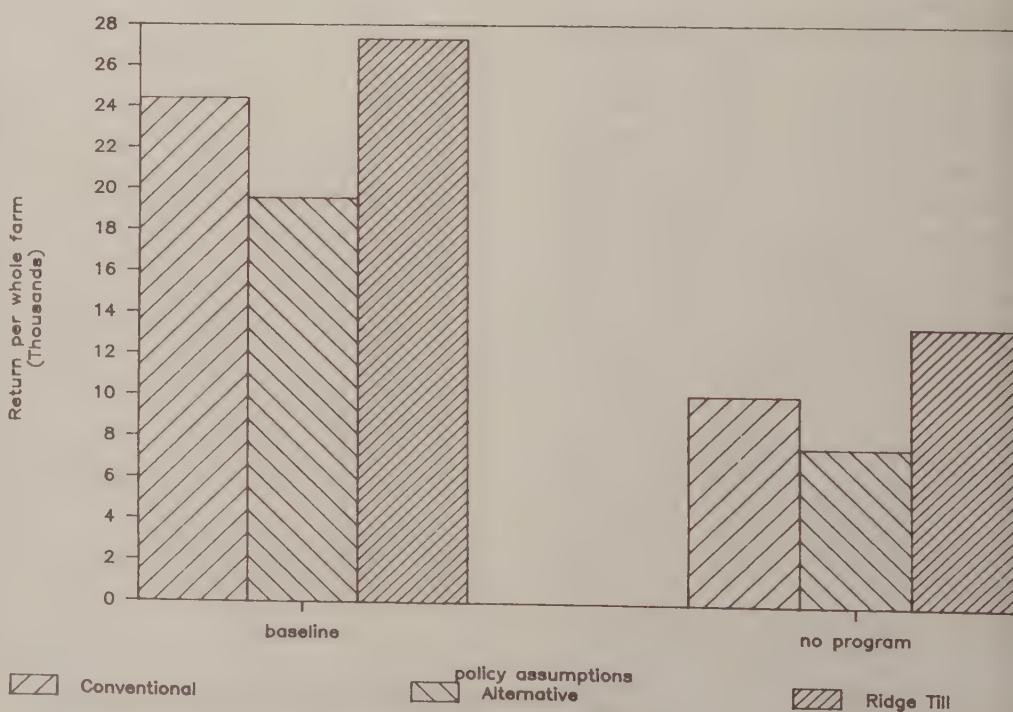

Figure 5. Comparison of farm net returns for the systems in Farming Systems Study I (a) when there are 1987 Federal farm program provisions in effect ("baseline" situation) and (b) when there is no Federal farm program ("no program" situation).

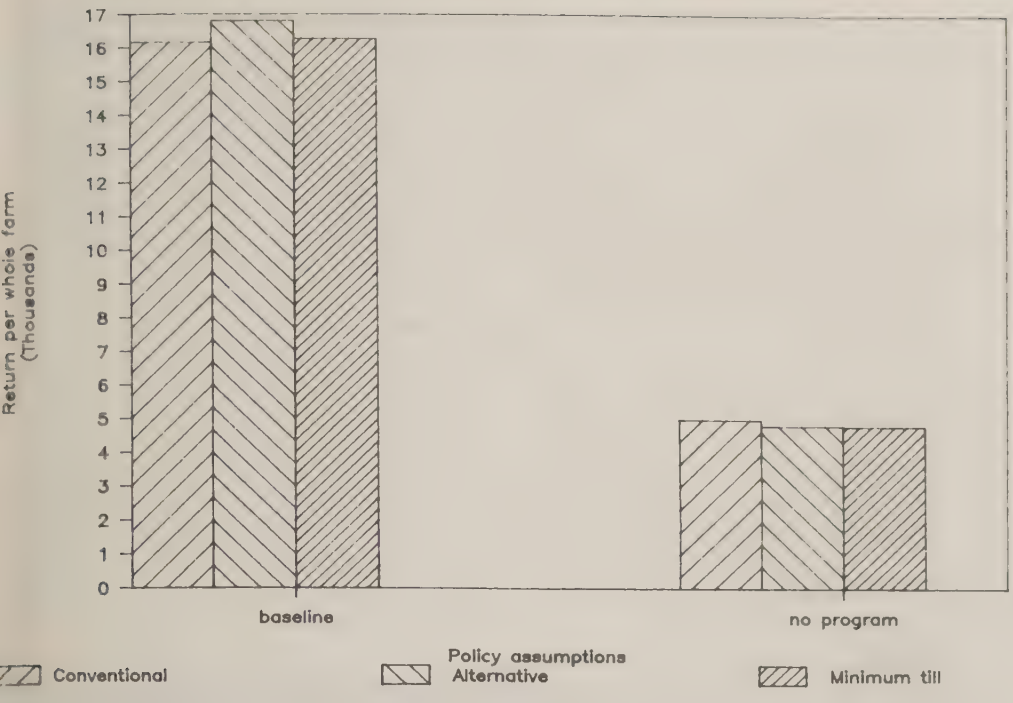

Figure 6. Comparison of farm net returns for the systems in Farming Systems Study II (a) when there are 1987 Federal farm program provisions in effect ("baseline" situation) and (b) when there is no Federal farm program ("no program" situation).

orderings of the systems did not change (Figure 5). This was not the case when these new assumptions were incorporated in FSS2 farming systems, however. There, the net returns decline was greatest for the alternative system, causing that system to drop from its initial position as most profitable (Figure 6). The alternative system became slightly less profitable than the conventional system in FSS2 and became roughly equal in profitability to the minimum till system. The diminished attractiveness of the FSS2 alternative system is explained by elimination of set aside requirements in this particular "no farm program" scenario; that elimination reduced some of the advantage of sweet clover in the alternative system.

Further analysis involved allowing alfalfa hay prices in the alternative system of Study I to decline along with grain prices, in the "no farm program" scenario. Expansion of forage production would likely result if current farm programs were eliminated, putting downward pressure on hay prices. When alfalfa hay prices were reduced to 70 percent of their baseline levels--at the same time that other crop prices were set at 70 percent of 1987 target or market levels--*both* the absolute and the percentage declines in net returns were greater for the alternative system than for the conventional and ridge till systems in Study I.

Some of these analyses support the hypothesis that conventional farming systems are more adversely affected by reductions in Federal farm program support levels than are alternative systems. However, the findings indicate there can be important exceptions. The future course of Federal farm policy can have critical implications for the competitiveness of alternative farming systems.

Conclusions and implications

Results of our baseline analyses show that alternative farming systems can be competitive with more conventional systems in at least some situations. The alternative systems entail markedly lower direct costs, and one of the alternative systems has approximately the same net returns as the comparable conventional and minimum till systems. The other alternative system has positive but somewhat lower net returns than the comparable conventional and ridge till systems.

Sensitivity analyses indicate that one alternative farming system requires *yields* about 5-10 percent above those of the comparable conventional system to produce the same net returns. The other alternative system is competitive with a conventional system even with yields 5 percent lower. Long-term research trials underway in South Dakota will therefore be important in determining the precise relationship of alternative to conventional system yields under Northern Plains conditions.

One of the alternative farming systems is competitive with more conventional systems even with current *chemical fertilizer and herbicide prices.* Sensitivity analyses reveal that the other alternative farming system becomes competitive (in terms of net returns) with more conventional systems when fertilizer and herbicide prices rise by 50 percent. Although real (inflation adjusted) increases of this magnitude are unlikely to occur over the next several years, they are possible over the long term.

Sensitivity analyses demonstrate the critical impact of *Federal farm program support levels and acreage set aside requirements* on the relative competitiveness of different farming systems. In some cases, reductions in farm program benefits increase the economic competitiveness of alternative or low input farming systems.

However, sharp reductions in farm program benefits could cause alternative system farmers who start out with comparatively lower but nevertheless positive net returns to experience acute financial problems. Although the negative impact from reduced farm program benefits might sometimes be greater for conventional than for alternative system farmers, the conventional farmers may be better able to survive financially because of superior starting positions. Thus, some alternative system farmers could be more likely than their conventional counterparts to have to dip into net worth to meet family living expenses and, thereby, to encounter solvency problems when farm program benefits are reduced.

Moreover, the sensitivity analyses show that certain changes in or elimination of the Federal farm program sometimes can have a greater absolute negative impact on alternative system net returns than on conventional system returns. For example, this is the case with the alternative system in FSS2, which includes sweet clover as acreage set aside. These results suggest that not only the *level* of future farm program benefits, but also the *form* of program provisions and compliance requirements, will affect the relative competitiveness of low input farming systems.

On-going agronomic investigations of tillage practices, fertility, and yield levels are critical to a more thorough understanding of alternative farming system economic feasibility. Crop rotation and tillage combinations in addition to those analyzed in this study also need to be examined. Further, more extensive investigations into the impact of Federal farm policies on alternative farming system competitiveness are needed. In this regard, implications of the conservation compliance provisions of the Food Security Act of 1985 merit greater attention.

The multiple roles of livestock in alternative farming system economic feasibility and the availability of animal manure for soil fertility also deserve greater attention. Our investigations in those areas go beyond the scope of this article, however, and will be reported separately.

Acknowledgments. Numerous individuals in SDSU's Plant Science and Economics Departments have contributed directly or indirectly to the research reported in this article. We want to especially acknowledge Lyle Weiss, however, for his role in developing crop enterprise budgets used in this study. Also especially appreciated were the helpful review comments of Marty Carson, Diane Rickerl, Donald Taylor, and Douglas Young. Funding for the research was provided by the SDSU Agricultural Experiment Station. This is South Dakota State University Agricultural Experiment Station Journal Article No. 2315.

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UPCOMING EVENTS

November 14-17. Natural Resources for the 21st Century, in Washington, DC. The purpose of the conference is to bring together experts from a variety of fields to explore new directions for conservation organizations and management agencies as they move into the 1990's and beyond. Contact the American Forestry Association, P.O. Box 2000, Washington, DC 20013.

November 16-17. Make It by Marketing Conference, in Lancaster, Pennsylvania. Sponsored by Penn State Cooperative Extension and others, especially for Northeast growers of natural and specialty foods. Contact the Short Courses Office, Penn State University, 306 Agriculture Administration Building, University Park, PA 16802.

November 28-30. 1988 Acres U.S.A. Conference, in Kansas City, Missouri. Contact Acres U.S.A., P.O. Box 9547, Kansas City, MO 64133.

December 8-9. Soil-Building Cropping Systems Conference, in Lewistown, Montana. Sponsored by the Alternative Energy Resources Organization (AERO), to examine soil-building systems for the Northern Rockies and Plains. Topics include production issues such as rotation choices, interseeding options, innoculation, weed control, harvesting and marketing issues as well as the program and policy barriers to introduction of legumes and other green manure crops into this region's cropping systems. Contact AERO, 44 North Last Chance Gulch, Helena, Montana 59601, (406) 443-7272.

January 2-5, 1989. International Federation of Organic Agriculture Movements' Seventh International Conference, in Ouagadougou, Burkina Faso, Africa. The conference will address the theme of agricultural alternatives and nutritional self-sufficiency. Contact IFOAM Conference, Ecocentre Imsbach, D-6695 Tholey-Theley, Federal Republic of Germany.

January 14-19, 1989. American Association for the Advancement of Science Annual Meeting, in San Francisco, California. For information, contact AAAS, 1333 H Street, NW, Washington, DC 20005.

February 28, 1989. Sustainable Farming Systems: Diversity and Integration, in Washington, DC. Symposium goals include an examination of the characteristics of low-input, integrated farms and those policy barriers that limit the broader adoption of these diversified systems. Contact the Institute for Alternative Agriculture, 9200 Edmonston Road, Suite 117, Greenbelt, Maryland 20770.

Improving the relevance of formal education and training in preparing international students as change agents for low-input agriculture

Kristin Cashman and Edgar Persons

Abstract. *The frequent assumption that there are relevant and meaningful parallels between agriculture in the U.S. and in Less Industrialized Countries (LICs) is critically examined. Based on the results of a survey of LIC students enrolled in the College of Agriculture at the University of Minnesota, recommendations are made to more carefully focus the approach and direction of LIC student eduction. We conclude that the education and training of agriculturalists in U.S. institutions of higher learning does not relate sufficiently to the resource base and domestic needs of farming cultures in the LIC countries. A case is made for the benefit of practical experience through work with farmers whose practices and applications accommodate and reflect the realities of low-input farming practices in the LICs. Appropriate paralleled farming systems in the U.S. are typified as "organic," "biological," "regenerative," or "sustainable," and LIC students could be given experience on these farms as a part of their degree program in school.*

Key words: Foreign students, University of Minnesota, less-industrialized countries (LICs), agricultural technology, organic farming, sustainable agriculture

Introduction

Agriculture in Less Industrialized Countries (LICs) is constrained by serious resource limitations. Farmers in LICs are estimated to number about 109 million, or 80 percent of the world's farming population (OTA, 1981). However, on average they operate on less than 11 acres of land; 39 percent have fewer than 2.5 acres. LICs are characterized by subsistence farming with under-capitalization, minimal education, and limited resources (Harwood, 1979).

This situation contrasts sharply with agriculture in Western countries where the technology has "leaped ahead." Western practitioners and academicians often leave the impression with students from LICs that advanced technologies are transferrable to wholly different circumstances in other regions in the world. As major teaching institutions, universities are centrally involved in the process of technology transfer. However, the unconscious and unwitting acceptance of instruction in Western agricultural techniques by students from LICs has led to a growing concern about the relevance of the education and training LIC students receive at U.S. colleges of agriculture (Barrier, 1985; Blumberg, 1986). Studies indicate that international graduates of these colleges frequently are uncritical and imitative practitioners of knowledge that was generated in other contexts and for purposes that are not suitable to the small farm in the LIC (Blumberg, 1986).

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The problem

The optimism of the sixties and early seventies that was generated by the promise of transferring modern agricultural technology to solve the food production problems of LICs has faded. These technologies yielded spectacular results only in situations where soils were fertile and other production factors were optimal. However, such conditions are found in less than 29 percent of the arable land of LICs (OTA, 1981).

The bleak agricultural situation in LICs emanates not just from the lack of resources, but from the well-documented application of inappropriate technologies. The role played by teaching institutions in the transfer of these technologies can easily lead to what Alatas (1968) has called the "captive mind syndrome." A captive mind is the uncritical, imitative product of a higher institution of learning, in this case typically a U.S. land-grant institution, whose method is conditioned exclusively by Western perspective and thought.

Background

In 1977, the U.S. land-grant system increased its involvement in international agriculture under the auspices of Title XII, a 1975 amendment to the Foreign Assistance Act of 1962 (U.S. AID, 1978). The intent of the amendment was to bring national expertise to bear on world food problems by recognizing the contributions that land-grant universities have made to American agriculture. Ideally, LIC agriculture would derive the benefits of instructional and research departments and agricultural extension

services linked to land-grant universities. Williams (1978) summarizes the strategies of the 1862 and 1890 land-grant colleges that should continue to be extended to LICs under the auspices of Title XII as follows:

1. Involvement of the people to be served in the planning for community and resource development.
2. Identification and utilization of indigenous leadership in program implementation.
3. Helping people help themselves.
4. Hands-on experience and demonstration teaching, in addition to basic research and theoretical instruction.

A major response to the Title XII amendment has been the education of international students at U.S. land-grant institutions. As a result, 25 percent of all graduate students studying agriculture in the United States are from LICs (Barrier, 1985).

The critical issue

In 1980 the National Association of Foreign Student Affairs (NAFSA) held a workshop to address issues of technology transfer. A recurring theme in their discussions was the imperative need for practical training to enhance the student's self-reliance and capacity for adoption of Western innovations. Recommendations put forward by the commission include the following:

Practical experience, through some type of internship which could constitute part of the degree program so that schools could formally assist students, particularly those in certain fields. Relevant practical experience can enhance the application of knowledge learned in class (Lee et al., 1981, p. 69).

A major theme can be drawn from the literature on the relevance of U.S. education to students from LICs: there are inadequacies in the application of the knowledge gained in the U.S. to the situations the students will face in their home countries. Students and alumni from LICs emphasize that practical experience is needed along with formal education to provide the self-confidence to enable them to act independently and fulfill the role of innovator and adaptor (Hathaway, 1977; Byrnes, 1980; Coleman, 1984).

Research design and methods

Previous studies examining the relevance of U.S. education provided to agriculture students from LICs have relied on written surveys with predetermined and standardized categories. Studies of this nature stop short of making specific recommendations to enhance the rele vance of this education. According t psychologist A. Maslow, "Too much o this categorizing leads to rigidity an lack of awareness of the present. It als leads to ineffective problem solving New problems are either unrecognize or handled with inappropriate tech niques, (or) old solutions that do not fit," (Maslow, 1987, p. 188).

For this study, open-ended interview were conducted with 30 internationa

Table 1. Characteristics of International Student Sample

A. Background by Country

No. of Students	Country of Origin	National Farm Data	
		Average Acreage	% Labor Forc
5	Nigeria	10.3	90
4	Indonesia	2.6	66
2	Brazil	95.8	56
2	India	16.1	69
2	Iraq	18	47
2	Kenya	10.4	82
2	Philippines	8.9	53
1	Barbados	.4	61
1	Iran	14.9	46
1	Columbia	—	79
1	Ghana	6.5	58
1	Ecuador	20.1	51
1	China	3.1	68
1	Peru	50.3	70
1	Bangladesh	5.8	86
1	Algeria	11	61
1	Morocco	11.4	57
1	Thailand	8.6	80

B. Geographical region of students in sample

No. of Students	Percentage	Region
11	37	Asia
10	33	Africa
6	20	Latin America
3	10	Middle East

C. Program of Study of students in the sample

No of Students	Percentage	Program
6	20	Animal Science
6	20	Agronomy
5	17	Ag. Engineering
5	17	Ag. Economics
3	10	Soil Science
2	6.5	Plant Pathology
2	6.5	Plant Breeding
1	3	Forestry

D. Degree Track of students interviewed

No. of Students	Percentage	Degree
24	80	Ph.D.
5	17	M.A., M.S., M.Ag.
1	3	Undergraduate

students enrolled in the College of Agriculture at the University of Minnesota. To ensure adequate representation the population of 160 LIC students enrolled in the College of Agriculture was stratified by department and country. A random sample was chosen from each stratification. The 30 students selected by the random process represented the 160 LIC students enrolled in the College of Agriculture at the University of Minnesota (Table 1).

To understand and capture the points of view of the students, this study adopted a semi-structured interview format (Gordon, 1969), which allowed the participant to respond at length to the questions posed. Also, to avoid leading questions, Spradley's (1979) developmental research sequence was used.

The interview (Table 2) was constructed of three principal areas: survey of the participant's background and educational experience; perception of the agricultural situation in the home country; and examination of the relevance of specific coursework to the work anticipated in the home country.

Using Berelson's (1952) inductive content analysis, themes were identified in the responses, and appropriate categories were formulated. Questions were selected which represented the common themes in order to illustrate and humanize the data and address the major research question: "How can the educational experience of students from LICs be made relevant to the agricultural needs of their countries?"

Information was selected from the United States Department of Agriculture's *Report and Recommendations on Organic Farming* (1980) because of its relevance to low resource use agriculture. It was used to determine whether the student responses were relevant to a low resource use context.

Table 2. INTERVIEW QUESTIONS

BACKGROUND INFORMATION

1. How long have you been in the U.S.? In Minnesota?
2. Do you have an urban or rural background?
3. What were your parents occupations as you were growing up?
4. What was your work experience prior to arriving in the USA?
5. Did you have any background or training in agriculture?
6. Does your family own any land?
7. What is your major source of funding?
8. What position will you occupy upon your return home?
9. Who will be your employer?

AGRICULTURAL SITUATION IN RESPONDENTS' COUNTRIES

1. What do you consider to be the three most important agricultural needs in your country?
2. What are the solutions for the problem areas you have identified?
3. What do you consider to be the most important technological innovation in agriculture introduced in your country?
4. Can you describe any innovations that were not successful?
5. What are the indigenous sources of fertilizers, pesticides and farm machinery?
6. What percentage of the farm sector is composed of small-scale farmers? Does national research and development reflect this?
7. Are farm families receptive to new technologies? Why?
8. Are you aware of any detrimental effects of agricultural practices on the environment?
9. Is there a long-range plan for agriculture in your country? If so, what?
10. In your opinion, should there be any agricultural development in your country? If so, how should it take place?

EDUCATIONAL TRAINING AT THE UNIVERSITY OF MINNESOTA

1. Describe how your present education and training is going to be useful when you return home. What have you learned that can be useful when you return home?
2. How would you change the training program at the University to help you bridge the gap between what you are learning here and the situation in your country?
3. What field experiences or practical application have you received in your training program?
4. Describe a program for field experience in the University's College of Agriculture that would help you in addressing the needs of your country's agricultural sector.
5. What is the subject of your thesis research? Were your needs or those of your country considered in topic selection?
6. Based on your answers, do you have any additional suggestions for improving your agricultural training at the University?

Research findings

Participant's background

The majority of the students had spent more than two years at the University of Minnesota (Table 3). More than half came from urban areas and land-owning families; less than half had any actual farm experience. Sixty-three percent of those interviewed were scholarship recipients and were obligated to return to their countries to perform agricultural service upon completion of their academic program.

Perception of agricultural situation at home

According to 87 percent of the participants, the primary goal of their country is self-sufficiency in agriculture. Yet 80 percent said most capital inputs that were used on American farms (at least what they could assess from their exposure in class) were considered scarce, erratic in supply, or virtually unavailable to farmers in their own countries.

Many students perceived that farmers in their country practiced diversification of the farm system to reduce risks and that small farmers tried to maximize available resources by selecting various crop and livestock enterprises that have complementary requirements.

The majority of the students interviewed perceived that the factors that limit the productive capacity of the agricultural sector in their country were poor soil fertility, water shortages, absence of agricultural inputs, and lack of local, regional, and national infrastructure. The majority of the participants looked to the development of, and training in, appropriate technology as one of the solutions to these problems.

Student responses that describe the typical situation in LICs are shown below.

Typical Agricultural Situation in LICs

(factors identified by respondents)

- predominant means of national sustenance
- R & D emphasizes cash crop production

Table 3. Student Responses to Queries on Agricultural Experience

Query	Response	Number	Percentage
1. Years of study in U.S.	1 year	6	20
	2 years	13	43
	3 years	7	23
	4+ years	4	13
2. Sources of Funding	government	12.5	42
	U.S. AID	3.5	12
	World Bank	3	10
	research assistant	7	23
	private	2	6.5
	other	2	6.5
3. Background	city	19	63
	rural	11	37
4. Occupation of Parents	government	13	43.3
	private	13	43.3
	farming	4	13.3
5. Land Ownership	none	11	37
	10 acres	4	13
	50 acres	7	23
	over 300	2	7
	absentee	4	13
	communal	2	7
6. Work Experience	teaching	10	33
	research	17	57.
	none	3	10

- labor intensive
- little or no available farm credit
- marginal land under production
- cash inputs unavailable
- small scale (90 percent of farms are less than 5 hectares)
- farm population with low education & literacy
- chemical inputs misused, environmental & human contamination
- misuse of available resources
- black market interference
- declining productivity, soil erosion & deforestation

Relevance of specific coursework

In light of the students' past experience in the agricultural sectors of their native countries, it was important to determine what aspects of the educational program in the U.S. were considered valuable. "Learning to conduct research" was the highest response category (30 percent). But, there was often no positive response in this area.

When asked what students from LICs need to learn to cope with the agricultural situation in their countries, a recurring theme identified by using Berelson's (1952) inductive content analysis was the need to learn how to analyze existing environments and socio-cultural data. However, a majority of the participants said they lacked instruction about how to interpret and extrapolate research formulated in the U.S. Students often noted, for example, that small farmers in LICs engage in mixed crop-livestock systems. Yet in the agricultural schools in the U.S., research focused on single crop or livestock enterprises in isolation from other variables in the total farm system.

Sixty-three percent said their agricultural training at the University of Minnesota lacked relevance, leaving them unprepared to deal effectively with agricultural problems in their countries.

The majority said more instruction is needed about optimizing production with limited resources. The complexity of problems faced in the farm sector of LICs makes interdisciplinary collaboration essential, but their training left them unaccustomed to working together to solve common problems. In reaction to these views, those interviewed were challenged to describe what can be done about this and how. The approach taken was role-playing, in which the student was assigned the position of Dean of the College of Agriculture. The task was to describe and recommend an appropriate training program for students in agriculture from LICs. Typically, the responses referred to incorporation of appropriate field experiences which would expose students to resource-efficient farm technologies adaptable to diversified farming systems.

Conclusions and recommendations

The Report and Recommendations on Organic Farming (USDA, 1980) concluded that the regenerative nature of organic farming in the U.S., including the objectives, practices, problems and solutions encountered on organic farms is quite similar to low-input farming systems in LICs. Such low-input systems include: the development of favorable micro-climate and a diverse biological balance on the farm; soil building programs including composting of farm wastes, green manure applications and the use of legumes and salinity management; proper tillage techniques; self-reliance to as great an extent as possible in personal food and energy supplies, feed and fertilizers; and the collective development of the rural economy and community (USDA, 1980). Farming systems of this nature in the U.S. are referred to as "organic," "biological," "regenerative," and "sustainable."

Much of the U.S. Department of Agriculture report parallels the responses from and recommendations made by students to improve the "relevance" of their university experience. Yet 86 percent of the participants knew nothing about organic farming or similar low-input systems in the U.S.

While students had many suggestions for improving the training they had received, there were seven recommendations which were supported by a significant number of the respondents.

A most frequent suggestion for program improvement was to include an extended field experience as part of the academic programs that would enable students to make appropriate translations and applications of classroom material to agriculture in their countries.

Refocusing the direction and approach of student research to encompass

the technical and socio-cultural components and limitations of LICs' farming systems was the second most popular response. Studies should be directed towards increasing the productivity and welfare of small farming households at all stages of the production cycle.

Several suggested that vocational training in operating and modifying equipment would be useful. Since the size of most LIC farms precludes the use of modern machines as used in the USA, skills learned in operating and modifying machines to better fit LIC conditions would be a useful addition to the training scheme. The introduction of animal traction and internal combustion power is dependent upon an understanding of how machines can be designed and operated to improve farmland performance.

Most LIC farms are not specialized, but rather depend on a diversity of crops and livestock enterprises. Several students suggested that training should encompass some study of the techniques employed by diversified farm producers rather than focusing only on the techniques of specialized farms.

Most students recognized the importance of optimizing the returns or utilization of different factors of production, but had little study or experience in how to accomplish the task. Students had few suggestions on how to be better prepared in resource utilization decisions. Since this is a topic frequently addressed in courses in agricultural economics or farm management, a solution to the dilemma expressed by students may be to broaden their program of study to include more attention to the economic and management factors in production.

Students recognized that much of their education was knowledge-based rather than skill-based. Many suggested that a better balance between skills and theoretical knowledge would be useful. This balance was particularly important when the students saw themselves in roles where they would have responsibility for managing or supervising the entire production process, even if their concern was with some more theoretical aspect of the problem, such as might occur in a research station project.

The last major recommendation centered around the necessity to view technology in the context of the limited availability of resources. Almost all recognized limited resources as one of the characteristics of their home country. Yet many lamented the fact that their study and usually their research was done in the context of abundant resources. Without conscious practice or experience they were not confident that they could make the transition from knowledge applicable to abundant resources to knowledge applicable or adaptable in a context of limited resources.

Several authors reviewed as the background for this study support the recommendations made by the sample of students from the University of Minnesota.

"If American universities are to be serious in the training of foreign scientists for problem solving in developing countries, the students should have in their training, classroom, and field experiences more opportunities to apply the techniques, knowledge, and tools they have acquired to the kind of situations and problems faced in developing countries" (Hathaway, 1977, p. 69). Harwood (1979) suggests that such research should be planned and carried out in collaboration with resource-efficient farmers. This approach would demonstrate the value of collaboration between farmers and scientists in the identification of problems and the implementation of solutions through agricultural research.

One way land-grant universities could administer practical, appropriate field experiences for educational purposes is to take advantage of the internship program developed by the International Federation of Organic Agriculture Movements (IFOAM). IFOAM's program, "Working Weekends on Organic Farms" (WWOOF) is a network of farmers using low-input farming methods. It embodies several objectives identified by the students interviewed: "direct experience with resource-efficient farmers, experience working on diversified farms to find interdisciplinary solutions to farm problems, and an appreciation of the farmer as a valuable partner in the research, development and technology implementation process" (IFOAM, 1983).

Perhaps the greatest challenge in LICs is the development and diffusion of appropriate, sustainable agricultural technologies to meet growing demands on the world's food supply and associated environmental problems. This challenge can be addressed by improving the perceived relevance of the education and training students receive in U.S. universities. They will be the change agents responsible for developing and transferring relevant technology in agriculture in their home country. But whether in the U.S. or in an LIC, any agricultural production system, if it is to be effective, must be designed to help farmers solve production problems and meet their goals. Therefore, the natural preoccupation of our colleges of agriculture with domestic issues need not restrict our ability to address agriculture problems of other countries. But it may require a different look at how programs of study for foreign nationals are designed and implemented, and an adjustment in the attention given to the adaptation or adoption of new technology under limited resource conditions.

It would not be appropriate for U.S. institutions to direct all of their attention in agriculture to low-input conditions. Neither would it be appropriate to adjust programs of study to include only those areas of interest which students identify as important. But it *is* appropriate for both programs of study and the context of study to be informed by the conditions under which technology will be learned and applied. It is not too much to ask that universities consider the perceptions and assessments from students who come from LICs as they plan ways to improve the relevance of their institutions to the larger world in which we live.

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OPINION—continued from page 2

and waterways. The grass from up to 4 percent of the land (13 acres), at a yield of at least 1 ton/acre, would easily be consumed by the cows and their calves. Conservation also implies crop rotations, typically involving wheat, oats, and alfalfa or other legumes, in addition to row crops. Pasturing the cattle on the wheat, and feeding the oats and legumes, makes this rotation plausible. The proposed herd size seems sufficient to sustain an ambitious soil-conserving rotation on 320 acres.

The manure from 30 cows with calves, a bull, and 12 yearlings on feed will not be enough to meet all the fertilizer requirements of 320 acres. However, this is not an insurmountable obstacle. Fertility on a well-managed organic farm involves other factors besides livestock manure: A crop mix that includes crops with reduced fertility requirements; the positive effect of crop rotation on yield from factors unrelated to nutrient supply; nitrogen fixation by legumes; and yield goals chosen because they are most efficient, not necessarily the highest attainable. Also, the farmer can use additional organic sources of nutrients, such as fish meal or kelp, although this may be less profitable than increasing the livestock herd.

Recycling of nutrients and organic matter is not optimized in the model farm because not all the feed grains will be consumed on-farm. Finishing the 26 yearlings might require 50 bushels of feed grain each, or 1300 bushels. Additional grain would be used to creep-feed calves on pasture, but together these uses constitute only a small fraction of the total grain production, which would likely be between 5,000 and 10,000 bushels. (The cattle also recycle nutrients by grazing pastures, waterways, and crop residues, and by consuming legume hay produced in the crop rotation.) Although selling some feed grains reduces nutrient recycling, it is permissable because it diversifies the sources of income, which contributes to financial stability.

The proposed livestock operation also increases the farm's financial stability because almost all the feeds are raised on the farm. This means that this important component of production costs is more under the farmer's control than if feeds were purchased. Also, by foraging, livestock yield some economi return even if hazards like drought or hail leave little harvest able grain crop.

Finally, livestock are important for the goal of reducin pesticide use because they permit the farm to be more diver sified, particularly through rotations with legumes. Also, winte grazing of feed grain residue will minimize volunteer corn an milo. The proposed herd will be large enough to be able t clean up the grain residues, taking account of the reduce proportion of feed grains under organic rotations.

The number of livestock proposed as meeting the require ments of organic farming is modest in comparison to curren practices. For example, consider my own county, Cass County Nebraska, which lies along the Missouri River on the western edge of the Corn Belt. It has about 333 thousand acres o farmland, mostly in corn and soybeans. It also has about 15 thousand head of livestock, including cows, cattle on feed, hog and sheep, or about one head for every 2 acres. The mode farm has 84 head of cattle (counting the cows, their calves, th bull, and the cattle on feed) on 320 acres, or about one anima for every 4 acres. Of course, quantitative comparisons of dif ferent types of livestock on a per head basis are not valid, bu the example shows that the livestock density of the hypothetica farm can legitimately be called "modest."

In summary, this paper is not equipped to provide a precise answer regarding whether livestock production in organic farming would be at appropriate levels. One reason is that appropriateness is partially a function of how much livestock products *should* be consumed. Part of the answer to that lies in nutritional debates which are not yet resolved.

A more modest conclusion, however, is that the too-much-livestock criticism of organic farming is currently without foundation. I argued that that form of attack on organic farming misuses its own device of argument, ignores the highly relevant subject of where current livestock production could be located, and fails to acknowledge that a surprisingly modest quantity of livestock can be organized to create a threshold of viable organic methods.

Feeding a Billion--Frontiers of Chinese Agriculture. 1987. By Sylvan Wittwer, Yu Youtai, Sun Han, and Wang Lianzheng. Michigan State University Press, East Lansing, MI. 462 pp. $30.

"The impacts of Chinese agriculture on the world food market by the 21st century may well compare with that of Japanese industry on world business in the 1980s," warns Sylvan Wittwer, senior author of *Feeding a Billion*.

This is the first jointly authored work on China by an American in conjunction with knowledgeable Chinese agricultural scientists, and one of the most comprehensive works in English on Chinese agriculture since F. H. King's 1911 classic *Farmers of Forty Centuries*. It presents an impressive array of up-to-date commodity and resource data regarding agricultural-production technology trends of the past decade, changes that have enabled China with 7 percent of the earth's arable land to essentially eliminate hunger for 22 percent of the world's population.

The book's 37 chapters aptly describe commodities, efficient food-producing systems and sideline industries that have developed during the transitional period from a state-controlled economy to a market-driven one. In this contract-responsibility production system (Zhe Renzhi), the state land owner returns the land to families and small groups to farm.

Sylvan Wittwer, Director Emeritus of the Agricultural Experiment Station at Michigan State University, effectively used five trips to the People's Republic of China from 1980 to 1987 to arrange with Chinese agricultural scientists to produce this remarkable volume on goals, achievements, and problems of the contract-responsibility production system that successfully has improved China's food-producing capabilities from 1978 to 1986.

Nine chapters, including the introduction and last two, are Wittwer's; the others are those of his Chinese collaborators. Individual chapters are devoted to particular grains such as corn, wheat, and barley, and to vegetables such as sweet potato and Chinese cabbage.

The success of Chinese agriculture is corroborated in the preface by Nyle Brady, Senior Assistant Administrator, Science and Technology, U.S. AID, and by laudatory dust-jacket comments by American authorities, Norman Borlaug of the International Maize and Wheat Improvement Center and John Hannah, Executive Director of the United Nations World Food Council.

The dramatic surge in food production began in December of 1978, when the 11th Congress of the Central Committee of the Chinese Communist Party, recognizing the disadvantages of overcentralized management in running people's communes, replaced the old inefficient practices with an output-related system that placed individual households in charge of production.

Under the new production-responsibility contract, economic incentives have been substituted for bureaucratic control. Farmers are asked to deliver a quota of farm products at a fixed price and to make payments to a common accumulation fund of a collective economic organization. Then, with the payment of this obligation, they are allowed to grow anything they want and to sell competitively for whatever price they can get on the "so-called" free market. Before 1978, they worked to meet the quota; now they work to meet the demands of the market. What and when to plant becomes an issue of profit and loss, and only the most profitable crops are grown.

Gone are communes and state farms, with their brigades of workers. Now much of the planting, tilling, and harvesting is done by individual farm families early in the morning and in the late afternoon, before and after working in the factories. Wittwer claims that today's China is the hallmark of success in food production and agricultural reform. Based on the accomplishments of the past decade, he predicts that Chinese agricultural production probably will grow at least twice as fast as the population and continue to make the positive advances responsible for his startling prediction noted in the first paragraph above.

Walking on two legs

With no additional land on which to expand, China's food increases have had to come from an across-the-board increase in crop yields and from improved natural-resource management that uses a curious mixture of ancient traditional experience and ultra-modern technology, a combination known to the Chinese as "walking on two legs."

Traditional methods

Traditional methods, meticulously described by King in his *Farmers of Forty Centuries* seventy-five years ago, include crop rotations with a legume; recycling of organic manures, and compost. Farmers use time to compensate for space limitations by transplanting, and employing multiple-, sequential-, and relay-cropping systems to obtain as many as two, three, or sometimes four crops a year from the same tract of land.

Intensive cropping systems and programs of water management that included irrigation and drainage have long been used to cope with shortage of arable land, floods in the south, and frequent droughts in the north that led to the old farming proverb: "...a good or bad harvest depends upon fertilizer, but water determines whether you get any harvest at all."

Modern methods

Today, with 116 million acres under irrigation, compared to 34 million in 1949, water conservation holds top priority, for, although first in popula-

tion, China is sixth of the world's nations in water resources. Sun states that water for crop irrigation is the most important factor in achieving dependability and increasing the magnitude of food production because rainfall is undependable, varying from season to season and from year to year.

Rice and sugarcane, two of China's important crops, are notoriously high consumers of water. In addition, the high plant density designs that efficiently use the five and one-half hours of sunshine that two-thirds of China averages daily also require large amounts of water. In no other systems are crops so demanding of moisture as in China's layered-vegetation plantings or relay-cropping systems.

Additional modern methods are being used to extend the margins of food production in many directions, including moves to combat the most feared environmental impositions, i.e., damages by weather, insects and disease. Plastics are revolutionizing crop production by increasing yields, extending the growing season and allowing the growth of more crops per year. They help solve the weather and climate problems by achieving higher and more constant temperatures; by conserving water by reducing evapotranspiration; by protecting plants against cold and freezing temperatures and hot and drying winds; and by protecting the seed-root bed against excessive downpours of rain and hail that cause soil erosion and compaction. In addition, plastics improve fertilizer availability and increase vegetative growth, as well as provide effective weed control.

Although use of inorganic chemical fertilizers tripled from 1975 to 1983 (the fastest rate of growth of any country using large amounts) and is expected to double between now and the year 2000, the ancient practice of incorporating up to 30 tons of long-lasting organic manures per acre per year is still popular. Top dressing with the more soluble inorganic chemical fertilizers provides instantly available plant nutrients.

The Chinese have no peers in their ingenious recycling and efficient use of human and animal wastes, peats and humic manures, green manures, and domestic and industrial wastes. Well-decomposed wastes are used for early maturing, short-season crops; less decomposed wastes for late-maturing crops. Yu states that pigs, 90 percent of which are privately owned, are fed mostly wastes and are raised primarily for the manure they produce.

China leads all nations in hybrid-rice research and had released ten dwarf rice cultivars by 1966 when the International Rice Research Institute released IR-8, its first of a series of "miracle rices." Likewise, breeding high-yielding, superior tillering, semi-dwarf and dwarf, insect- and disease-resistant, wheat cultivars has been largely responsible for China's becoming the world's leader in wheat production in 1984. Similar improvements have been accomplished in the germ plasm of the cultivars of corn, millet, sorghum, sugarcane, sweet potatoes, Irish potatoes, rape, peanuts, and countless fruits and vegetables.

Anyone interested in minimal use of toxic chemicals in farming should study the Chinese pest-management system that uses improved varieties, cultural practices, and integration of traditional biological insect and disease controls with limited use of commercial pesticides to control insects and disease.

Pork production has been increased without a major increase in the number of sows by increasing the number of litters per year, the number of weaned piglets, the number of fattened pigs for sale, the carcass weight of each pig, and the percentage of lean meat.

Fish production has been increased by penning pigs near fish ponds so that the pig manure can nourish both the pond's vegetation and the fish. Mulberry trees grow on the dikes so that silkworm feces and pupae fall into the ponds to benefit both vegetation and fish. Unlike the situation in the United States, pond eutrification is considered beneficial and the products periodically are removed to fertilize field crops.

By "walking on two legs" the Chinese now export rice, wheat, corn, and soybeans, and lead in the production of wheat, rice, sweet potatoes, rape seed, sesame, pears, chickens, ducks, geese, rabbits, and products of aquaculture. They are second in corn and peanuts, third in soybeans, and fourth in production of sugar and sunflowers.

Current and potential problems

With all of these accomplishments, however, the new Chinese system is not free of problems and the future holds many questions according to Wittwer. Some include maintaining quality in handling the vast production, including the post-harvest handling, packaging, storing, transporting, processing, distributing and marketing, especially of the perishable produce.

How long can a system survive that pays some farmers ten times the amount paid to government officials, airplane pilots, or factory workers while the majority are the lowest paid in the nation? What and how much mechanism can be introduced to the countryside without a wholesale replacement of farm workers so that "they leave the soil but not the village, and enter the factories but not the city?"

Will the individual households continue the integrated pest-management system previously conducted by the collectives?

Can the current annual 5 percent agricultural growth be maintained and the goal of quadrupling the 1980 production be achieved by the year 2000?

Can today's successful family-planning program be continued through this century?

Will the Chinese be able to solve the rural energy problem?

Will the current recognition by academia, the press, and the central government of the environmental problems of air pollution, soil erosion, water pollution due to the precipitous rise in nitrogen-fertilizer usage, and acid rain be sufficient to help solve these formidable problems?

Can the ever-present problems of nitrogen loss and pathogenic organisms associated with recycling of organic wastes be controlled?

continued on page 47

COMMENTARY

Resolving conflicts in American land-use values: How organic farming can help

Frederick Kirschenmann

Key words: Puritans, theocracy, crop production, soil stewardship, property rights, erosion, ecology, environmental pollution, sustainability

One of the more intriguing questions confronting those of us concerned about soil and land conservation is the question of why Americans, and especially American farmers, use (or abuse) the land the way we do. It is probably safe to assume that each of us uses land in accordance with a set of values, expectations, and perceptions that we have developed over time. In other words, we use land in accordance with our own philosophy of land use.

That may seem so obvious as to appear trivial. But it is instead an important point. All too often we approach the issues of land conservation through the concept of "good guys" versus "bad guys". The "good guys" are people who plant trees, install grass waterways, strip crop, no-till and do everything possible to keep their soil from being exposed to erosion. The "bad guys," conversely, are the people who bulldoze out trees, rip up the waterways, cultivate whole quarter-sections as a single field, fall plow, and appear to be insensitive to the problem of their eroding soils.

Given this point of departure, we have tended to see the task of land conservationists to be that of converting, cajoling, or coercing the "bad guys" into complying with the conservation practices of the "good guys."

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I think that is a simplistic and incorrect analysis of the problem. Indeed, it is perhaps one of the reasons why our solutions are often ineffective.

In America we have, in fact, developed a philosophy of land use that contains some conflicting values. Understanding the tension caused by those conflicting values, I think, will go a long way toward explaining why some of us try to preserve the land while others of us abuse it.

Prosperity versus virtue

People of European descent who came to this country were caught up in a "dream of destiny." They believed that they came to these shores because they were especially called, chosen by God, to build here a new "kingdom of God on earth." In *The Lively Experiment*, Sidney Mead (1963) has demonstrated how this sense of destiny among Americans is rooted in the early Puritan theocracy.

But this mandate had two prongs. On the one hand, the early settlers considered it their destiny to clear the land, tame the wilderness, and make the land productive. In other words, clearing the trees and rocks and breaking up the prairie and planting nice, neat rows of corn was a moral obligation--one of the reasons God had placed them here. The extent to which they "progressed" in this way was, in fact, considered a "sign" that they were fulfilling their destiny. The Native Americans who had refused to "improve" the land in this way were considered "lazy" and therefore not deserving of any claim to the land they inhabited. (For a compelling study on this subject see William Cronon's *Changes in the Land* (1983).)

This set of values, expectations, and perceptions about land use is deeply embedded in our history. It leads us to feel morally obligated to make the land as productive as possible, to "prosper" on it, to make it yield its maximum potential. That is part of the philosophy of land use we have all inherited.

On the other hand, the early settlers also regarded it as their destiny to preserve and protect the land. This land was, after all, a gift from God, entrusted to them as a place of freedom--freedom to worship God, freedom to develop their own moral character, freedom to fabricate a body politic that more nearly resembled the kingdom of God. In other words, preserving and protecting the land, safeguarding it and taking care of it was seen as a moral obligation, one of the reasons why God had placed them here. And, again, the extent to which they were able to preserve the land as a heritage and a place in which the virtuous life could be pursued by others was a "sign" that they were fulfilling their destiny.

Accordingly, there is a second set of values, expectations, and perceptions

relative to land use equally embedded in our history. This heritage makes us feel morally obligated to preserve the land and protect it for future generations.

Obviously this two-pronged dream of destiny spawned philosophies of land use about which honest, responsible people could disagree. In fact, it has created conflicting feelings about land use within most of us. Consequently, whenever economic needs and the desire to prosper appear crucial, we can be moved to make fragile land available for logging or crop production and relax the restrictions that were put in place to preserve and protect the land. And whenever the need to preserve our heritage for the future appears crucial, we can just as easily be moved to restrict the mining of our natural resources and intensify measures to protect and preserve the land.

But the interesting thing is that whenever conflicts over land use arise each side in the conflict tends to regard the other side as immoral. Land developers who level trees and create nice green lawns regard environmentalists who interfere with their creation as meddling obstructionists. Environmentalists who try to save trees and preserve the environment in its natural state regard land developers as greedy destructionists. But, in reality, it's not a case of "good guys" versus "bad guys." It's a matter of conflicting convictions about how the land should be used.

I experience these conflicting values in myself.

On the one hand, I'm motivated to do the best job of farming that I can. It's a moral obligation. I feel that I "must" put in place those practices that will enable my land to produce to its maximum potential. Anything less would be irresponsible. So, if my land produces best when I fall plow, or drain sloughs, or break up a piece of prairie, then that is what I feel obligated to do.

On the other hand, I'm motivated to do the best job of taking care of the land that I can. I feel I "must" protect the land so that it will continue to be here for future generations, so that they can be assured a place of their own where they can be free to develop a quality life. And if protecting the land this way means leaving the stubble, preserving the natural environment, and putting good conservation practices into place, then that is what I feel obligated to do.

All this is not to dismiss desire for material gain as a motivating factor in the way we use land. We probably all have a streak of this motive in our characters and sometimes use land to satisfy our material ambitions. But it cannot be substantiated that this is the primary cause of land abuse. It is, rather, the need to prosper, to demonstrate progress, to show improvement, to have the best wheat field in the county--that's what really motivates most users of the land.

Private rights versus stewardship

There is a second set of conflicting values, also embedded in our history, that further determines the way we use land: the obligation to protect private property rights and the obligation to practice stewardship.

The rights of private property, including land, were close to the hearts of the framers of our Constitution. The Sixth Amendment made it clear that land belongs first and foremost to individuals and that the rights attending such ownership were not to be easily interfered with by the state. In other words, Americans, from the beginning, felt a moral obligation to protect the right of the individual to use his land as he sees fit.

However, since the settlers who came here felt providentially chosen to build a kingdom of God on earth, they also had a strong sense that the land never belonged to them at all, that it was only entrusted to their care. That made them not so much owners of the land as stewards.

Again there is obvious potential conflict in these values which are so much a part of our philosophy of land use. Along with other Americans, I also feel this set of conflicting values in myself.

On the one hand, I view my land as *my* property--the place where I decide what is best for me without outside interference. It is important for me to protect that right, not only for myself, but for my neighbors and for future gen ations.

On the other hand, I view my land a trust--something that never really b longs to me, something that was he before I came and will still be here lo after I'm gone, something that w placed into my care for a brief period time.

Since both values are part of me, can passionately endorse a proverb th has emerged in our time: "Treat the la as if you borrowed it from your childre rather than as if you inherited it fro your ancestors." But, I can also endor with equal passion, the outburst of farmer who was irritated by a wildli officer's efforts to dissuade him fro draining a slough on his own land: "G the hell off my land. I don't need son damned bureaucrat telling me how farm."

Inevitably, of course, the paths of o lives lead some of us to be more infl enced by the values of developing a vi tuous life and practicing stewardshi while others of us are more influence by the values of prosperity and protec ing the rights of private property. Co sequently, in any area of the natio conflicts over how land should be use are almost certain to arise.

Until we realize that these conflic grow out of opposing values which a part of our national philosophy of lan use, deeply carved into the moral fabr of the nation, we are not likely to d velop a practical land conservation pr gram that the majority of American will support over the long term. Recog nizing that our conflicts over how th land should be used are rooted in co flicting sets of values, and not in a d vision between "good guys" and "ba guys", is the first step toward reconcilin our differences and moving toward comprehensive land conservation pr gram.

In fact, there already exist some prac tical approaches to reconciling the land use conflicts that arise from these tw sets of values. First, we need to replac short-term thinking with long-ter thinking. Second, we need to discove and disclose the inherent connections be tween economy and ecology.

Short- and long-term thinking

Another trait that is deeply ingrained in American culture is our tendency to seek quick, easy, short-term solutions. The development of this trait in our national character can probably be attributed to the availability of space and resources throughout most of our history.

Settlers in the new land were seldom in a situation where they had to negotiate their way out of a difficult problem or concern themselves with the long-term effects of their actions. The option of leaving an unpleasant situation to start over in a new location on the frontier was usually available. Americans learned that they could mine any situation for its wealth in the short term without worrying about the consequences in the long term.

That short-term thinking also has become an integral part of our philosophy of land use. Prior to the introduction of synthetic fertilizers, farmers on the plains tended to "use up" land by breaking up sod, farming it until the soil nutrients were depleted, and then moving on to a new piece of sod. There was little incentive to devise a soil building system that restored and preserved the soil, let alone protected it from erosion.

After the appearance of synthetic fertilizers, purchasing inputs became the new quick, short-term solution. It never occurred to most of us to consider the long-term effects of making agriculture dependent on these external inputs nor to assess the long-term effects of applying these synthetic materials to the soil.

But in the 1980s, we have run out of new space. So we are forced to look hard at the long-term effects of the way we use the nation's land. Rather than being negative, however, this fact has the potential of leading us to reconcile the conflict in our land use values. Wendell Berry (1977) hinted at the possibility of such a reconciliation when he wrote that "A people cannot live long or well at each other's expense, or at the expense of their cultural birthright." One of the lessons of history is the fact that whenever a civilization mines its soil to enjoy short-term prosperity, that civilization suffers long-term famine and poverty.

This inherent long-term connection between prosperity and conservation was recognized by a group of German scientists commissioned by the Bonn government in 1979 to research future directions for agriculture in Germany. They recommended that the government de-emphasize short-term profitability in favor of long-term adaptability. They concluded by saying that "ecology is long term economy." (See John Seymour and Herbert Girardet, *Far From Paradise* (1986).)

In other words, viewed in the long term, preserving the land's natural ecology for future generations *is* the most prosperous way to use the land. A healthy bottom line for a few years doesn't necessarily add up to a prosperous farm. Prosperity can only be maintained when the soil and its environment are properly cared for, not when prosperity is derived at the expense of the soil. When we look at land use in the long term, the potential conflict between prosperity and virtue disappears.

Viewing land use in the long term can also begin to resolve the private property/stewardship conflict. Once we begin thinking in the long term, we begin considering our children's children. Consequently, the "rights" we want to ensure for ourselves within our private property protections begin to join with the welfare of our offspring and the stewardship required to guarantee them the same rights.

However, part of the solution to the private property/stewardship dilemma lies in simply recognizing that *both* values are in each of us. If both those values were clearly introduced into discussions between farmers and wildlife officials over swampbuster regulations, for example, it could help both sides recognize that the conflict is between two land values and not two groups of people. That could help to remove some barriers and enable everyone to work together toward some kind of compromise solution.

Natural connections between economy and ecology

There are numerous inherent connections between ecology and economy, in the short as well as the long term.

One of the reasons that the Soil Conservation Service's no-till program met with such initial success was that it disclosed numerous ecological *and* economic advantages over conventional tillage systems. That program may have problems (both ecological and economic), but it still stands as an example of what can happen when we take the time to discover and disclose the connections between ecology and economy.

Economic and ecological connections are also evident in conventional agriculture, although in a countervailing way. On the surface, it appears that conventional agricultural methods, which are ecologically questionable, are eco-

USDA expands rural information program to six states

The USDA information service for rural development programs has been expanded to six states (Illinois, New Mexico, Iowa, Vermont, Georgia, Missouri) and will move toward national implementation in 1988, announces the National Agricultural Library. The service is designed to answer questions on how rural communities can develop or maintain a competitive, diversified rural economy. In response to questions, a computer-generated copy of information sources is sent to the user. Actual publications can then be obtained through interlibrary loans. For information, contact Patricia John, Coordinator, Rural Information Center, Room 304, National Agricultural Library, 10301 Baltimore Boulevard, Beltsville, MD 20705, (301) 344-2547.

nomically sound. But more economists are recognizing that the cheap food produced by fewer and fewer farmers within our conventional agriculture system is not the good deal we thought it was--because not all of the costs have been factored in.

We haven't factored in the cleanup costs of decontaminating our ground water, for example. We haven't factored in the costs of restoring the soil which has been eroded and salinized at unprecedented rates. We haven't factored in the taxes used to subsidize the oil and water required to produce crops conventionally. We haven't factored in the costs of social destabilization caused when large numbers of farmers were lost from rural communities. Nor have we factored in our increased health care costs, clearly related to conventional agricultural practices (Center for Rural Affairs, 1984). If we were to factor in all of these costs, it would become painfully clear that we cannot prosper economically, even in the short term, without attending to ecology.

Conversely, there is now some compelling evidence that more sustainable agricultural practices are economically advantageous.

Economic advantages of sustainable agriculture

The economic advantages of sustainable systems are not as simple as removing the "chemicals" line-item from farm budgets, as is sometimes implied by the press. Neither are they simply demonstrated by producing research data showing organically managed fields producing comparable yields to conventionally managed ones, but with lower input costs.

Such studies are, of course, important, especially when they investigate new techniques such as the perpetuating-alternative-legume-system (Goldstein and Young, 1987). But such field demonstrations typically still focus only on the results of *part* of a farm's operation. To determine whether there is a positive connection between the ecology and economy of a sustainable farm, we need to determine whether the farm as a *whole* is more prosperous.

The Lockeretz et al. (1978) study comparing 14 midwestern organic and conventional farms was a step in this direction, but it still concentrated on year-end bottom line crop production results--only part of a farm's operation.

To get a real grasp of the ecological and economic connections in an operating sustainable farming system, we need to look at the whole farm. My on-farm experience indicates that there are some clear-cut economic advantages to a sustainable operation, but they may not always show up as fatter cash balances. Furthermore, we need to keep in mind that additional costs inevitably occur in establishing and maintaining a sustainable farm.

Additional costs include such things as:

- The cost of establishing a viable crop rotation. There are additional storage facility costs, additional equipment costs, additional labor costs, perhaps even the cost of giving up part of some government program "base" acres.
- The cost of developing a soil building system. Primary costs in this area are related to establishing a diversified farming operation crucial to a sustainable system. Ideally, diversification includes livestock, so there are all of the costs related to building a livestock facility.
- The cost of creating a sustainable environment. Included in these costs are planting and maintaining trees, grassed waterways, wildlife habitat and permanent vegetative cover. While government programs provide assistance in this area there are still substantial maintenance costs.

Despite these added costs, however, actual farming experience demonstrates there are economic advantages to a sustainable system. The principle economic benefits include:

- Increased survival capability. Part of this has to do with the fact that diverse systems are more stable and spread out risk. A farm that has both livestock and crops, for example, is not as easily devastated by a hailstorm. Another part of survival capability is acquired from the increased efficiency of diverse systems. On our own 3,000 acre grain and cattle farm, for example, neither the grain nor the cattle operations in isolation fro each other turns a profit. But togeth they support each other so that bo become more profitable. The increase efficiency comes from the benefits th one part of the operation brings to t other. Approximately 40 percent of ou crop fertility needs come from the liv stock manure. Conversely, whe weather conditions inhibit crop deve opment sufficiently to disqualify it as cash grain crop, we can harvest it as fee for the livestock, mitigating the loss. E ficiencies are also derived from the re sidual effects of sustainable practice The effects of compost applications, fo example, can be observed for years while the effects of most water-solubl fertilizers are short-lived.
- Decreased vulnerability. Farms tha are not dependent on petroleum-base inputs are not as vulnerable to price in creases. A 1972-82 Holland study, fo example, shows that while conventiona Dutch winterwheat farmers during tha period experienced 130 percent cost in creases, bio-dynamic farmers during th same period experienced only 6 percen cost increases (Schaap, 1987).
- Environmental advantages. The di rect economic advantages of an environ ment free of chemical inputs can b calculated in terms of lower health car costs, reduced liability, and reduced on farm hazards. Some recent reports in dicate the adverse health effects of ag ricultural chemicals on farmers (Center for Rural Affairs, 1984). There is mount ing pressure to hold farmers liable for chemical contamination of ground water.

Organic farming

It is such reasons that are leading many farmers to begin farming organically. We are doing it because it makes sense both economically and ecologically. While organic farmers by and large have strong commitments to preserving the environment, they are also keenly interested in prospering. And while they want to be good stewards of the land, they also value their property rights. Organic farming is one way to embrace the best part of both sets of values in our heritage.

There are key economic and ecological differences between organic and conventional agriculture that can be summed up in one sentence: Organic agriculture seeks to cooperate with nature's system of production, while conventional agriculture seeks to create its own system of production alongside of (and, in some instances, even over against) nature's system.

That basic distinction can be illustrated in numerous ways:

- Instead of purchasing synthetic inputs to supply plants with basic nutrients, organic farmers put self-regenerating systems into place so that each part of the farm's operation feeds into and enriches other parts. By that method soil is continually enriched, providing a nutrient rich growing environment for plants.
- Instead of purchasing synthetic inputs to control weeds, organic farmers devise crop rotation systems that deprive weeds of the growing environments they need in order to thrive.
- Instead of purchasing synthetic inputs to control insects, organic farmers rely on natural predators to keep insect populations in check.

In short, instead of spending money to fight against nature, upsetting her well-balanced system, we try to cooperate with nature and let her work for us.

The ecological and economic connections of organic farming are aptly illustrated in a true story that took place several years ago.

In Grass Range, Montana, there is a young rancher by the name of Tom Elliot who owns and manages a large cattle ranch. Several years ago Tom noticed that leafy spurge was starting to take over his rangeland. So Tom called in some chemical advisors to help him develop a program to eradicate the spurge. They agreed on a program, and helicopters came and sprayed the spurge. The price tag was $25,000.

Almost immediately after the application, the spurge began to curl up and die. But the next Spring the spurge was back. So Tom brought back the chemical advisors. Together they developed a follow-up program. Once again the helicopters came. Once again the spurge began to curl up and die. Once again the price tag was $25,000.

The next Spring Tom noticed that the spurge had diminished some, but it was still coming back in undesirable levels. He also noticed that his pine trees were dying and that he had an abnormal number of diseased cattle, many of them carrying diseases they had never had before.

So Tom decided that chemical sprays could not be the answer. One day a neighbor told Tom that while cattle wouldn't touch spurge, sheep loved it. Then it occurred to Tom that he had a neighbor with a large herd of sheep and inadequate grazing land. The neighbor had been leasing rangeland some distance away and was eager to find pasture closer to home. So Tom and his neighbor drew up a lease agreement that allowed his neighbor to graze his sheep in with Tom's cattle. The spurge provided excellent pasture for the sheep, who thrived on it, and consequently kept it in check. Since the sheep preferred the spurge, they didn't deplete the rest of the pasture for the cattle. And Tom was now receiving a handsome income from the lease.

I'm not suggesting that all of agriculture's problems can be solved that neatly. But the story serves to illustrate that if we look for alternatives to the quick, short-term fix and try to discover and disclose the connections between economy and ecology, there are sometimes solutions right under our noses that make sense for our pocketbooks as well as for the environment. Overall, such solutions also allow us to begin resolving some of the conflicting values we have inherited about the land in America. And I think that if we begin developing our agricultural and our conservation programs using those approaches, we may just find ourselves with some lasting, effective land conservation practices in place that the majority of Americans would support over the long term.

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BOOK REVIEWS—
continued from page 42

How long can the Chinese continue intense farming practices that destroy soil organic matter and soil structure, especially of the problem soils now existing on one-third of their cultivated land?

Yet, Wittwer says, China is a model to be emulated by the developing nations, for it is a country that has essentially eliminated hunger. China, he says, has developed an ecological self-sufficient sustainable agricultural system that may interest advocacy groups looking for alternative food-producing technologies such as organic farming or sustainable or regenerative systems of agriculture.

Feeding a Billion, in this reviewer's opinion, should interest anyone contemplating living in the 21st century because the combination of the Chinese socialistic regime's land policy combined with its citizens' strong work ethic is bound to have a significant influence on life of the 2000s in the U.S. as well as in China. -- *Orville W. Bidwell, Professor Emeritus, Department of Agronomy, Kansas State University., Manhattan, KS.*

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Youngberg named for MacArthur Fellowship Award

Dr. Garth Youngberg, Executive Director of the Institute for Alternative Agriculture, was named on July 18 for a five-year, "no strings attached" MacArthur Fellowship Award by the national MacArthur Foundation. "This is an affirmation of the importance of low-input directions in the development of sustainable farming systems," Youngberg says. "And it is doubly significant since this is the first time that the Foundation has chosen to recognize the field of agriculture. Society needs to be more aware of the critical role that agriculture plays in all of our lives." Youngberg joins 30 other individuals ranging from jazz musicians to paleontologists who were named for Fellowships by the Foundation. Awardees are selected by an anonymous 15-member committee from proposals submitted by 100 anonymous nominators; over a five-year period, each receives an amount upwards of $150,000, varying according to the age of the recipient. Youngberg has been the Institute's Executive Director since its foundation in 1981. "Garth brings unique analytical and communication skills to the double task of framing issues in alternative agriculture and taking those issues to the front of the national debate about policy and research priorities," says Jim Lukens, President of the Institute's Board of Directors. "We're glad those skills are being recognized."

IAA board member, editor receive conservation awards

Maureen Hinkle, Director of Agricultural Policy at the National Audubon Society and a member of the Institute for Alternative Agriculture's Board of Directors, and Sara Ebenreck, Consulting Editor at the Institute, both received 1988 Honor Awards from the Soil and Water Conservation Society at its meeting in Columbus, Ohio, in early August. Hinkle was named for her contributions to the enactment of the 1985 Food Security Act. Ebenreck was recognized for her writing and editing of multiple articles and publications related to soil and water conservation. SWCS President Donald Van Meter presented the awards.

'88 low-input grant projects are underway

Project selection for 1988 funding by the USDA low-input grant program, a program which the Institute has strongly supported, was completed in July, 1988. A sampling shows the diversity and "whole systems" approach of the projects:

- Demonstration of year-round dairy farm forage systems including intensive grazing and low-chemical approaches, aimed especially at farms on sloping land with low pH soils (Cornell Cooperative Extension and others).
- Solarization and living mulch used to optimize low-input production systems, for blueberries and strawberries (cooperatively, research stations in Texas, Mississippi, and Georgia).
- Development of a farmer/extension/research network and database for low-input agriculture (cooperatively, Winrock International, ATTRA, Meadowcreek Project, Arkansas Cooperative Extension and others).
- Collection, evaluation, and distribution of information on low-input production of legumes, grains, and vegetables by Hispanic farmers and Indian Pueblos in Northern New Mexico (Talavaya Native Crops Research Project).
- Development of an on-farm research network in Kansas (Kansas Rural Center).
- Videotape on sustainable, low-input agriculture (University of Nebraska).

Although some of these projects can be effectively completed in one year, "in many cases, it will take multiple years to fully achieve objectives," comments USDA program coordinator Patrick Madden. The Institute has supported multi-year funding of the program. As of early September, 1988, the Senate Appropriations Committee has recommended $5 million in FY1989 funding, while the House Committee has recommended that funding stay at the 1988 level of $3.9 million.

A copy of the list of "Low-input/Sustainable Agriculture Research and Education Projects for 1988" is available from the USDA Low-input Program Office, Suite 342, Aerospace Building, U.S. Department of Agriculture, Washington, DC 20251-2200.

New agriculture "fast approaching full flower," *Kiplinger Letter* says

A new kind of agriculture which "many considered an embryonic movement that would die aborning" is "fast approaching full flower," comments a front-page article in a recent issue of the national *Kiplinger Agriculture Letter*. Farm price support, animal health, land use, and food safety regulations will all see the effect of new consumer and environmentalist concern, Kiplinger says. Farmers are "showing a lot more interest in biological pest controls, crop rotations...the use of fewer chemicals." It's "important the farm/food industry be aware of what's going on," Kiplinger sums up.

Guide for authors

AJAA will publish original research on biological, physical, or social science aspects of alternative agriculture. We particularly welcome multi-disciplinary studies, but papers from a specific discipline also are invited. However, since AJAA readership is much broader than for a single-discipline journal, highly specialized terminology should be explained or avoided. The significance of a statement, or the reasoning behind a conclusion, may have to be spelled out more than in a more specialized journal. Research papers usually should be no longer than about 20 double-spaced pages.

Nomenclature and technical details

Research papers should use the International (SI, or metric) system throughout. Write out "liters". "Metric ton", although not strictly an accepted SI unit, can be used for data referring to "ordinary life," such as national crop output, as opposed to experimental data. Occasional use of common unit equivalents in parentheses is permitted, mainly for relatively exotic SI units.

The binominal or trinominal designation of a plant or animal species, and the cultivar where relevant, should be given in parentheses the first time the common name of the species is mentioned. Either name may be used thereafter. The same applies to names of chemicals that have both a common name and a chemical name. Do not use brand names except where the chemical is produced under a unique brand name. In those cases the brand name, identified as such, may be given the first time the chemical is mentioned. Nutrient applications should be given in elemental form (N,P,K). Oxide forms can be used in describing commercial fertilizers.

Title page

The title page should give the following information (all flush left): 1) title of the paper; 2) names of authors; 3) affiliation and office address of authors, and 4) acknowledgements, if any. See examples in this issue of AJAA.

Abstract

The abstract should be 200 to 400 words suitable for readers from a broad range of disciplines. It should avoid highly-specialized terminology that might be appropriate for a single discipline journal. Take particular care that the significance of the work is made clear, even to readers from a different field.

Reference list

References should be listed in alphabetical order by author's name, and by year for a particular author (with letters after the year if needed). If a sole author is also the lead author of papers with multiple authors, use the following order: single author (by year); two authors (alphabetically by second author's name); three or more authors (by year). Repeat the author's name for each reference. Use initials only for first and middle names. Give the names of all authors in the reference; never use "et al."

Use full names of journals, institutions, conferences, etc., except for extremely familiar abbreviations like "Dept." Remember that an abbreviation familiar to you may not be familiar to readers outside your field. If in doubt, write it out.

The reference list uses no quotation marks, italics, boldface, or underlining. Only the names of books and periodicals are in initial capitals. Names of papers, book chapters, pamphlets, and bulletins are not capitalized. Page numbers are written out in full (e.g., 1108-1123, not 1108-23). The volume is given if page numbers begin at 1 for each issue.

Citing references

Cite references in the text by last name and year, with chapter or page numbers if the reference is a book or lengthy report. For two authors, give both names. Do not use "et al." unless there are at least three authors.

Footnotes

AJAA does not use bibliographic or substantive footnotes. All bibliographic references should be at the end of the text. Instead of substantive footnotes, include the material in the main text or consider eliminating it.

Manuscript preparation

The entire manuscript, including abstract and references, should be typed on one side of standard-size paper, double spaced, with margins of at least one inch all around. Starting with the title page, label all pages in the upper righthand corner with the lead author's last name and the page number. Do not use hyphens unless the hyphen is part of the word. Do not underline anything except species names.

Follow the section headings style used in this AJAA issue. All headings are flush left, with no underlining or italics.

Tables should fit on one page, be numbered consecutively with Arabic numerals, and be on a separate sheet. Leave extra space to separate columns. Every figure and table should be mentioned at least once in the text.

Submission of manuscripts

Submit four high-quality copies to Editor, American Journal of Alternative Agriculture, Suite 117, 9200 Edmonston Road, Greenbelt, MD 20770. The cover letter should state that the manuscript is an original contribution that has not been published elsewhere in substantially the same form; that it is not currently under consideration elsewhere, and that permission has been obtained for any copyrighted material used.

How you can help support the scientific and educational needs of a sustainable agricultural system

A growing number of Americans have become concerned about the long-term sustainability of our food production system. Farmers and agricultural scientists are among those raising questions about the growing dependence of modern farming on nonrenewable resources, the depletion of our resource base through soil erosion, and heavy reliance on chemical fertilizers and pesticides. Continued heavy reliance on farm chemicals is questioned because they have become an expensive production input. Their widespread use also raises questions about human and animal health, food quality and safety, environmental quality, and the continued demise of the family farm.

Low-input alternative farming methods address these economic and environmental challenges. Alternative production systems point the way toward more profits, more individual choice, and long-term sustainability for our food system. More must be done to develop effective ways to make sure research, education, and information sources are readily available to farmers who want to adopt these techniques.

The Institute for Alternative Agriculture needs your help in meeting this challenge. We are a nonprofit tax-exempt research and education organization set up in 1983 to encourage and facilitate the adoption of low cost, resource conserving, and environmentally sound farming methods. We work directly with government agencies, colleges and universities, producer groups, and other institutions that provide research, education and information services to farmers.

The Institute also provides these services:

- *A resource to lawmakers and others who influence agricultural research, education, and information policy*
- *A voice for alternative agriculture in Washington*
- *A sponsor of research and education outreach programs*
- *A national clearinghouse for information on alternative agriculture*
- *A publisher of reliable scientific information on agricultural sustainability*

If you're interested in helping us, please contact our office at 9200 Edmonston Road, Greenbelt, MD 20770. The phone number is (301) 441-8777.

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